University of Alberta

The Technological Origins of the Modern Ocean Liners – a Revaluation of the *Great Eastern*'s Failure Theory

by

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Abstract

The thesis investigated mainly the developments in iron-hull design, demonstrating that the *Great Eastern* steamship, which maritime historians regarded as a complete failure, was in fact a technological success that greatly added to the development of gigantic ocean liners in the early twentieth century. The paper challenged the *Great Eastern* failure theory and demonstrated that the *Great Eastern*, designed by Isambard Kingdom Brunel, had a great impact on the development of the modern ocean liner. Brunel's' design enabled the ships to be built out of iron plates that were later riveted to the web of transversal and longitudinal watertight bulkheads. The *Great Eastern* was successful as the model for future shipping design and her rib-less iron hull, cellular flat bottom, watertight compartments, and the distinctive look of her hull based on the hydrodynamical experiments, were followed on all gigantic ocean liners of the twentieth century.

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Chapter 1

Introduction: Beginning of the Steamship Era

Between 1830 and 1850, the world experienced a rapid increase in sea travel. The expansion of the British Empire and the growing emigration to the new world created a demand for safer, more predictable and bigger ships. Although the steam engine was utilized as a boat propulsion system as early as 1783, it was not until 1838 that two ships, the *Sirius* and the G*reat Western*, used steam to travel across the Atlantic Ocean.[1] From 1838 onwards, more ships were constructed than ever before. The first transatlantic passenger company the British and American Steam Navigation Company, was established in 1838 and the Cunard Line followed in 1840.[2] For the first time in history, ships were constructed specifically to carry hundreds of cabin passengers across the four oceans. In the period between 1850 and 1900, the passenger steamships revolutionized the shipping industry. Their grandeur surpassed that of any previously constructed vessels, and they dominated world travel. The great steamships changed patterns of immigration and the method of conducting commerce and also speeded up international communication. While important work has been done on the importance of ocean liners during the period when they dominated world travel in the nineteenth and twentieth centuries, less work has been done on the technological origins of the great ships. This thesis will examine and revaluate the crucial historical event that led to the development of the gigantic ocean liner — Isambard Kingdom Brunel's ambitious effort to build his third and greatest ship, the *Great Eastern*. This thesis will argue that despite the many problems that plagued the *Great Eastern* and prevented her from becoming a successful ocean liner, she was a technological success and led the way to modern ocean-liner construction. Thus, contrary to maritime historian John Guthrie's argument that "The *Great Eastern* had nothing that other vessels didn't have, she simply had a lot more of it,"[3] this thesis will argue that the *Great Eastern*, in fact, represented a true revolution in shipping and was based on a completely new and innovative idea.

Through examination of the primary sources including Brunel's sketch book, diary, and personal letters, as well as contemporary reports on the ship from the *London Illustrated News*, the *Times* and *Scientific American*, this thesis aims to disprove the commonly expressed belief that the *Great Eastern* was too far ahead of her time and technology and thus failed as an ocean liner, as the historian of the *Great Eastern*, James Dugan, claimed: "Brunel and Scott Russell built a capital ocean liner before there was power and technology to run one."[4] Peter Kemp also expressed the same view, writing, "The Great Eastern was a failure because she represented an attempted short cut. She was built before the advance in engineering design and technology could match her advance in size." [5] On the contrary, this paper will argue that Brunel's ship was a direct product of the times in which she was conceived, that she fit in with the industrial revolution, the growth of the British empire, the growing emigration to Australia, and that she exemplified the spirit of the 1851 world exhibition. In addition, this paper will also challenge the 'failure theory' of the *Great Eastern*, arguing that although she was a financial disaster, her design was an engineering success.

This thesis will examine the technological importance of Brunel's giant ship, arguing that Brunel's design, in fact, changed the course of ship construction and helped bring about the era of the gigantic ocean liner, which dominated world travel until the 1950's. The approach of this paper, however, is not that of technological determinism, for the argument is not that without Brunel's gigantic ship, the ocean liner would not have been developed, but rather, that this ship was an important step towards a new maritime design.

Modern historians have overlooked this important point and have regarded Brunel's monumental vessel, which represented a true revolution in shipping, as a complete failure. For example, Courtlandt Canby wrote: "The *Great Eastern* designed by Brunel and launched in 1858, was half a century ahead of her times, yet she was a total failure…."[6] This paper will challenge such theories and argue that the *Great Eastern* was a well-designed ship and an important precursor to the modern ocean liner. In the course of our study, we will discover that her financial failure resulted from bad management, and unfitness for the North Atlantic service, rather than the ship being "ahead of her times." Since the *Great Eastern* was originally designed to travel to Australia and India, she had no heating system. Although her iron hull was too cold for the passengers or the crew to travel on the Atlantic, the *Great Eastern*, for reasons unrecorded in the sources, was never used for her intended Australian service. Moreover, the number of misfortunes and deaths associated with the ship before and after she was completed caused the *Great Eastern* to lose the cargo that was vital for her success: passengers. Her construction, which claimed many lives; her unsuccessful launching in 1857 and the tragic deaths of many involved; the huge explosion on her first run; the death of Brunel; the death of her captain; and the bankruptcy of all the *Great Eastern's* owners[7] resulted in bad publicity that overshadowed her successful design. As one reporter in 1888 noted, "Even to the last her ill-fortune appeared to attend her…."[8] Thus, during her final auction, a violent storm developed, and later on, she broke loose from the tugboats and was left uncontrolled, with engines dead, at the mercy of the growing winds. Many hoped she would be destroyed in that storm, as one reporter indicated: "There may be many who, but for the loss of life it would have involved, would have been glad to hear that the Great Eastern had foundered in the last gale she rode through, rather than that she should undergo the last indignities of a breaking up."[9]

This paper will argue that the *Great Eastern* had no chance of proving herself as a worthy passenger vessel because the public had lost confidence in the ship before she could prove her worth. At the same time, by examining her misfortunes, we will discover that the ship was a superb vessel, for the damages that she suffered would have sunk or destroyed any other ship in existence. In fact, contrary to what most modern sources claim, she was praised as late as 1912 and regarded as a supreme and safe model for transatlantic ship design. An article in *Scientific American* stated:

> Over fifty years ago the great engineer, I.K. Brunel, working with that free hand which was accorded engineers of those days, produced in the "Great Eastern" a ship which was unsinkable by the ordinary accidents of the sea – a ship so sanely designed that, we do honestly believe, she might have survived even the extraordinary blow which sank the "Titanic". So nearly unsinkable was the "Great Eastern", so excellent a model (with certain modifications necessary for the present requirements) is for the naval architect of to – day to follow…[10]

Sadly, her only noticeable days of glory at sea came between 1865 and 1874, when she was employed to lay the first transatlantic telegraph cable, proving finally both her durability and sea worthiness. The primary sources available on the *Great Eastern* are vast, and her history is well described in both the American and the British sources. Because of her gigantic size, the *Great Eastern* was regarded as the "eight wonder of the world"[11] and gathered unprecedented publicity. Of particular importance are the sources found in the *London Illustrated News*, the *Times* and *Scientific American*. The *London Illustrated* and the *Times* are perhaps the best sources for the early period of the *Great Eastern*, while *Scientific American* is a useful source for the end and the legacy of the great ship. The *London Illustrated News*, the *Times* and *Scientific American* are important, for they present valuable technical data and details regarding the great ship, and also prove she was never intended as an Atlantic ocean liner, but rather, was to steam to India and Australia. As the *London Illustrated* stated, "[The ship's luxury] will only be fully appreciated when the Great Eastern is steaming majestically across the Indian Ocean with her living freight of some eight or ten thousand passengers to Calcutta." [12] These sources, however, downplay the role of Brunel in the project and misrepresent Scott Russell's role in the construction of the ship, claiming that he and not Brunel designed and built the *Great Eastern*. For example, the *Times*, as early as 1855, stated that she was " John Scott Russell's Leviathan ship." [13] The vast personal writings of Brunel and Scott Russell show that the *London Illustrated* and *Times* cannot be relied upon to provide an accurate account of Brunel's role in the *Great Eastern* project. For this reason, the articles from the *London Illustrated* and the *Times* will be used only to document the history and specifications of the ship, while Brunel's biographical information will come from the published collections of his letters and family documents that were used in Brunel's biographies by Sir Alfred Pugsley and L.T.C. Rolt.

The surviving letters of Brunel and Scott Russell indicate that the relationship between the two was rather bitter and that the construction of the ship was significantly affected by their disputes. The correspondence between Russell and Brunel also illustrates the true role that Brunel played in the creation of the ship, which has been downplayed by other primary sources and some historians. James Dugan, for example, in *The Great Iron Ship*, largely ignores the correspondence between Brunel and Russell and follows the *London Illustrated*'s and the *Times*' version of events. Dugan's version is incomplete, for it omits the events that took place behind the scenes during the construction. In particular, Dugan downplays the fact that Brunel was forced to take command over the entire project more than once due to Russell's mistakes and miscalculations. Dugan's version also does not accurately portray the personality of Scott Russell. His letters to Brunel indicate how arrogant and uncooperative he was and how his mismanagement of the company's finances, and hostility towards Brunel, caused the great ship to lose her identity as a predictable ocean vessel.

The ship's designs, published by Sir Alfred Pugsley and L.T.C. Rolt in their biographies of Brunel, indicate what might have influenced the final design of the ship. The first drawings by Brunel (c. 1851) show a ship that apart from its gigantic size, is not much different in its shape from other ships of that era [illustration 1]. Latter drawings of Brunel from 1854 demonstrate, however, a clear departure from the old school of ship's design [illustration 2]. The design from 1854 appears much more modern. In particular, the shape of the ship's bow and hull resembles closely that of the future gigantic ocean liners of the 20th century. None of the Brunel's biographers has explained this crucial change in the maritime development. Another primary source, the records of the Royal Society meetings, indicates that Brunel's revolutionary design was, in fact, largely influenced by Scott Russell's hydrodynamical experiments, which he conducted while he was working on the wave line theory.

Illustration 1. Sketch of the great ship by Brunel c. 1851.

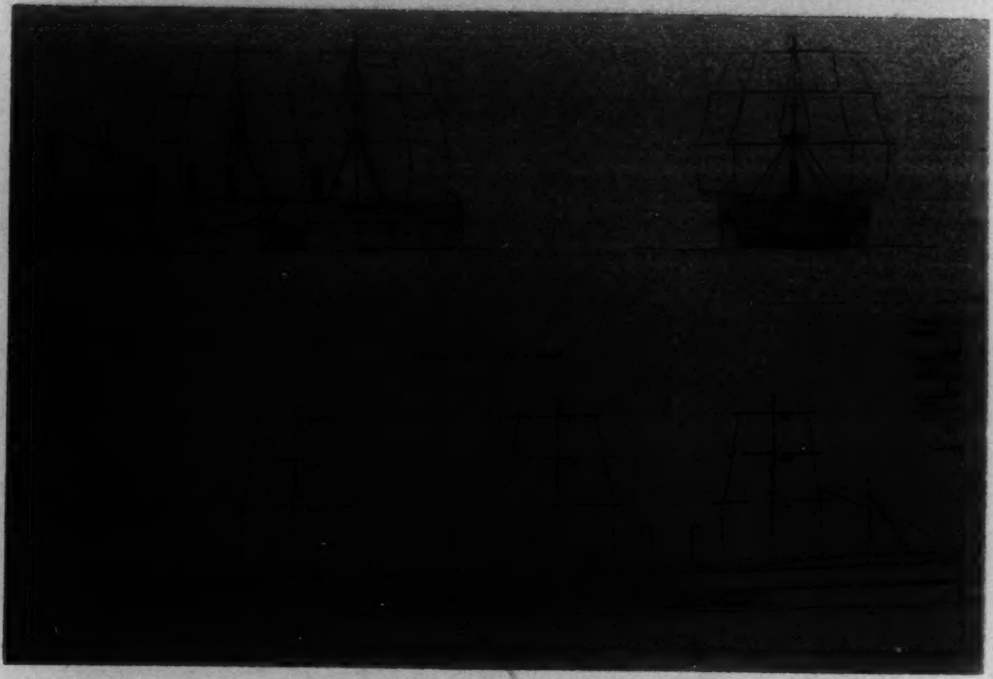

Illustration 2. Sketch of the *Leviathan* ship by Brunel dated May 1854

Most of Brunel's writings, especially his journal and personal letters, were studied and published by L.T.C. Rolt. These primary materials demonstrate Brunel's exceptionally innovative nature and diverse talents, which ranged from his ability to write poetry to his skill at designing locomotives. These materials also show how much Brunel was involved in the construction and design of the *Great Eastern*, as well as revealing his reasons for building such a gigantic ship. Although the secondary sources present most of these primary materials, these sources do not report the great ship's history accurately.

The secondary sources on the *Great Eastern* present some serious problems. Biographical works discuss the ship only as one amongst many of Brunel's projects and do not provide sufficient or accurate information about her. Books that discuss the developments of the shipping industry or history of ships in general mention her only as a "bizarre ship,"[14] a ship "ahead of its time,"[15] or an example of a "great failure."[16] The only secondary source that deals extensively and specifically with the *Great Eastern*'s history is *The Great Iron Ship*, by James Dugan, published in 1953. Since that time no single, historical book has been published on the *Great Eastern*. Consequently, Dugan's work remains the only complete secondary source on this subject. Unfortunately, *The Great Iron Ship* cannot be regarded as an entirely scholarly work. Dugan, although he tells the story in a passionate and engaging way and uses many primary sources, provides no footnoting or bibliography. His book also lacks any scholarly argument, and apart from telling a story of the 'iron monster' that was a failure from her beginning until her end, does not bring any new arguments to the historiography of the *Great Eastern*. Also, his work seems to be based on the author's genuine belief that the ship was ill-fated because a worker was sealed alive in the ship's double hull.[17] For these reasons, his work cannot be regarded as scholarly material, and this paper will demonstrate some of the main problems of Dugan's book, arguing, at many points, against the author's depiction of events and facts. Nevertheless, some of the primary documents including the ship's logbook, letters taken from Brunel's family, and other primary materials that are otherwise inaccessible, and that are presented in Dugan's book, will be used in this paper. Also, since *The Great Iron Ship* is the only existing complete historical account of the *Great Eastern* after Brunel's death, this book will be used as a secondary source, especially in the latter part of the thesis.

The secondary sources, in general, present the *Great Eastern* as a failure in terms of inadequate technology, oversized design, or poor financial judgments. Such views, however, are contradictory to the primary sources, which indicate that the size of the ship was well justified both financially and technologically. Since the publication of Dugan's book, the *Great Eastern* appears to have been regarded as a closed chapter in maritime history. Many authors took Dugan's work as the definitive representation of events, concluding that, in fact, she was an engineering failure and that "Brunel and Scott Russell built a capital ocean liner before there was power and technology to run one."[18] For this reason, the *Great Eastern*'s history and her possible impact on the development of the modern ocean liner were overlooked in scholarly studies.

The contribution of this thesis to the historiography of the *Great Eastern* will be a revaluation of the failure of the *Great Eastern* on the basis that the ship was well received by her contemporary society, and that her design was, in fact, successful and well justified in economic and technological terms. In order to provide such a justification, we have to first understand the *Great Eastern*'s historical background and Brunel's crucial role in the development of the first steam-powered transatlantic vessels. In the course of our inquiry, we will discover that the *Great Eastern* was not simply a result of Brunel's megalomania or desire to build the largest moving object that world had ever seen. Rather, his radical grand proposal had many practical justifications, which, in many cases, proved to be the way of the future. Thus, in contrast to the claim that "the Great Eastern could be read as marking a dramatic progression to ever greater size and ever greater waste of capital and coal"[19] this paper will argue that Brunel's final ship involved much more than simply a progression of size and resulting waste of financial resources. The *Great Eastern* and her revolutionary colossal design marked the beginning of the end of the wooden sail ships and, consequently, was an important step towards the passing from sail to steam.[20]

The sail ships are now only a distant memory; the new technology and resulting progression from sail to steam in the middle of the nineteenth century[21] gradually eliminated beautiful frigates, gigantic barks, and slim clippers. World War I and the U-boats caused the rest of the damage to sail shipping; consequently, by the end of the war, the large fleets of the tall-ships were only a thing of the past.[22] The few remaining veterans of the seaways were either deprived of their previous glory and converted into storage hulks, or were dismantled and turned into scrap. During the time when Brunel was designing his three famous ships, sails were by far superior to the steam, mostly because the sail ships were inexpensive to operate and much faster than the early steamers. It should be stressed, however, that the sail ships were operated as merchant vessels well into the 1930's, and that the introduction of steam power in 1850's did not result in the instant replacement of the old technology with the new. Captain Gustaf Erikson, for example, believed that the tall-ships could be operated successfully in the era dominated by the steam and diesel.[23] Because of him, some of the most magnificent ships in history were saved from destruction, refitted and put back, with much success, into regular ocean service.[24] Although Erikson managed to operate the *Pamir*, *Passat*, *Viking* and *Lawhill*[25] sail ships well into twentieth century,[26] and find them cargo for the most dangerous route to Australia around the Cape Horn, their days were numbered. With the tragic ends of the largest of the windjammers,[27] the *Preussen* in 1910, *France* II in 1922 and *Pamir* in 1957, only one gigantic sail ship remained: the 122.3-meters-long German *Magdalene Vinnen*, later known as *Kommodore Johnsen*, which after World War II, was given to the Soviet Union and was renamed *Siedow*.[28] In 1945, the last of the wooden engineless merchant tall-ships, Erikson's *Elakoon,* ended her life after being converted into a steamer, and the passing from sail to steam was thus completed.[29]

At the beginning of the nineteenth century, the wooden sail ships dominated world travel. Although faster[30] and more economically successful than the early steamers,[31] sail ships were proving increasingly inadequate and unsafe for moving the growing amounts of cargo and people across the oceans. As will be explained in this thesis' fourth chapter, the sail ships were replaced by the steamers mainly because the latter were much more predictable in terms of their ability to arrive at their destinations on time according to their schedules. Also, around 1860, a crucial shift occurred in the maritime developments from a focus on speed to one on comfort, safety and predictability. The Americans invested in the fast, unpredictable and unsafe wooden sail clippers while the British invested in steamers. The slow but highly predictable small steamers operated mainly by the Cunard Line established a transatlantic transportation system that operated according to regular schedules. The 'Cunarders,' as they were known, although slow and small, were by far superior to the sail ships because of their safety, comforts (even for the lowest class of passengers), and their highly predictable schedules. The steamers, however, were not employed immediately for the transatlantic voyages. Although steam power had been tested as a boat-propulsion system as early as 1783 when a small river ship named *Pyroscaphe* was equipped with a steam engine,[32] over fifty years passed by until in 1838, steam power was used to assist a ship in the ocean crossing. Because of that voyage, the possibility of steam navigation was considered. Moreover, Brunel played a major role in the early success of steam, since his ship the *Great Western* was the second steam vessel to cross the Atlantic Ocean.

The credit for the first transatlantic steam-powered crossing is generally given to *Sirius*, a small 703-ton displacement steamer equipped with a 300-horsepower engine.[33] She arrived in New York on April 23, after 19 days at sea, with an average speed of 6.7 knots and only 15 tons of coal left.[34] However, few historians have noted that the Atlantic had, in fact, already been crossed by two vessels fitted with the steam engines, *Savannah* in 1810, which had sailed from New York[35] and the *Royal William*, which had sailed from Pictou, Nova Scotia, in 1833.[36] These crossings were technically less significant since wind power was the main propulsion of these early sail-steamships. Both used auxiliary steam engines and did not use their engines for very long. The two ships had no tanks with fresh water, and the salt water which they used prevented the engines from being operated continuously. In both cases, the ocean crossing was made from the new world to the old, while *Sirius* was the first steamer to sail from Britain to New York.

The first-steam powered crossing of the Atlantic Ocean from Britain to America was a dream of many shipping companies and naval constructors in the 1830's. Ships such as the *Liverpool*, the *British Queen* and the *Great Western* were designed and built specifically for this purpose. Only the *Great Western*, owned by the Western Steamship Company, was ready on time. It was floated on July 19, 1837, at Wapping in Bristol harbour.[37] Faced with delays of their two ships the *Liverpool* and the *British Queen* and possible defeat, the British American Steam Navigation Company of London purchased *Sirius*, while the Transatlantic Steamship Company, based in Liverpool, purchased the *Royal William* (II). The *Great Western*, thus, was the only ship which was not refitted for the crossing, but was actually built for the purpose of the transatlantic race and was finished on time. Thus, it was not accidental that the *Sirius* and the *Great Western* sailed at the same time.[38]

The *Great Western* was the first of Brunel's three steamships. Built at William Patterson's shipyard in Bristol, she was made of oak and was 72.6 meters long. Her two engines delivered 450 horsepower,[39] and she had a displacement of 1320 tons.[40] Her size placed her amongst the largest ships in the world, but she surpassed them in the luxury and comfort of her compartments. Moreover, she had the largest and the most lavishly decorated ship saloon in the world. As were all of Brunel's ships, she was huge and at the same time extremely well fitted. On March 28, 1838, under the command of Lieutenant James Hosken and the supervision of Brunel and Captain Claxton, she finished her final trials.[41] On the same day, a small steamer, *Sirius*, owned by the British American Steam Navigation Company, sailed under the command of Lieutenant Roberts, bound for New York.[42] Some days before, Brunel wrote: "I cannot help still feeling some hopes that we may effect that most important object of performing the voyage across the Atlantic…"[43] Three days latter on March 31, 1838, the *Great Western* was on its way to pick up supplies and passengers at Bristol for her Atlantic race. However, a disaster occurred, almost causing the death of Brunel and destroying the ship. The *Great Western's* funnel appears to have not been properly insulated and to have caused the deck beam and deck planking, which was in contact with the smokestack, to catch fire.[44] In hopes of saving the steam engines and the boilers, Captain Claxton and Chief Engineer George Pearne managed to enter the boiler room and open the feed valves.[45] In the ship's log, Pearne described this event: "The fore stroke hole and engine room soon became enveloped in dense smoke, and the upper part in flames. Thinking it possible the ship might be saved, and that it was important to save the boilers, I crawled down…."[46] While Claxton was helping Pearne with the boilers, a heavy object fell on captain from eighteen feet above and knocked him down to the floor. It was Brunel. He was still unconscious when Lieutenant James Hosken managed to save the ship by running her aground near Canvey Island, where the fire was successfully put out.[47] The race appeared to have been lost. Brunel was immobilized and unable to attend the long-envisioned trip. Moreover, the fire caused the *Great Western* to lose most of her planned passengers, but she was afloat and in good working order. With the tide, the crew managed to get her off the mud and sail for

Bristol. Consequently, on Sunday morning at 10 am April 8, 1838, after some repairs had been done and with only seven passengers on board, she sailed for New York[48].

The *Sirius* had to refuel at Cork and pick up forty passengers, so she did not actually begin her transatlantic run until April 4. Brunel's *Great Western* thus left England four days after her, and with Brunel's steamer's departure from Bristol, the first trans-Atlantic steamers' race began. The *Great Western* took only 15 days and 5 hours, with an average speed of 8.8 knots, to reach New York at 4 pm, with 200 tons of coal still left.[49] Although she lost the race (by only a few hours),[50] she played a crucial role in this pioneering enterprise and in the following establishment of the transatlantic steam shipping industry. As L.T.C Rolt indicated:

> The achievement of the *Sirius* might have been dismissed as a bold stunt, but the appearance of the *Great Western* on the afternoon of the same day convinced America that this was no freak exploit but the inauguration of a new era of rapid and reliable ocean transport between the old world and the new.[51]

Thus, her coming was far more important than that of *Sirius*, which had almost run out of coal, because Brunel's ship and his design proved that the crossing could be done safely, quickly, and, above all, efficiently. On her return trip to Bristol on May 7, she carried 68 passengers and reached England in only 14 days. The *Great Western* turned out to be a great success, unlike *Sirius*, which was wrecked near Ballycotton on June 1, 1847 after her second and final trip to New York. The *Great Western*'s seventy-four Atlantic crossings proved that long-range transatlantic steamers were possible and profitable. Due to their fuel consumption and lack of durability on the high seas, the early side-wheelers did not result in the instant replacement of sails with steam. Although the race proved that both the ships and the engines were capable of traveling across the ocean, the first gigantic, durable, and publicly trusted steamship, the *Great Britain*, was not built until 1843. [52]

The growing passenger travel, the expansion of the British empire, and the public's practical needs, which called for safer, more predictable and durable vessels, made the 1843 construction of the *Great Britain*, the first iron transatlantic passenger ship, economically justifiable, while the products of the industrial revolution, such as iron plates and improved steam engines, made this project technologically possible. Consequently, the *Great Britain*, the second of Brunel's three steamships, represented many technological advantages over her predecessors and marked the beginning of a new era in the shipbuilding industry. She was the first vessel to be equipped with a screw as her main propulsion, and was also the first transatlantic ship with a hull built entirely of iron. She was also the first vessel that regularly traveled to America across the Atlantic. As a result, most historians have regarded her as the first 'ocean liner.' Her size, 99 meters long and 3675 tons of displacement, also set new standards and represented a clear departure from the older steamers. Her four engines, capable of producing an unprecedented 1500 horsepower, were utilized to turn her six-blade propeller of 5 meters in diameter,[53] and her watertight compartments opened new possibilities for the steamers and set new directions in ship design. On her first trip to Australia in 1852, she carried 630 passengers, while during the Indian Mutiny (1858), she carried 1,650 troops and 30 horses.[54] The *Great Western* and *Great Britain*[55] proved beyond all doubt that the way was now open for even more spectacular steamships. The time had come to build the 'eight wonder of the world' and Brunel was the one to do so.

Around 1851, Brunel envisioned his greatest ship, the *Leviathan.*[56] By that time, he had a great deal of experience in shipbuilding and was well aware of the problems and limitations of the contemporary maritime designs. Brunel's two ships placed him on the cutting-edge of contemporary technology. The *Great Eastern*, known as the *Leviathan* before 1857, was to be unlike any other ship constructed before. In design, luxury, size, and purpose, she represented a true revolution in shipping. As Captain Mahan indicated in his recollections,

> Naval officers who began their career in the fifties of the past century [1850's], as I did, and who survive till now [1907], as very many do, have been observant, if inconspicuous, witnesses of one of the most rapid and revolutionary changes that naval science and warfare have ever undergone.[57]

During a time when sea travel was dominated by wooden ships with a maximum 3,000 tons of displacement and a length of 70 meters, Brunel's monster was designed to have 27,419 tons of displacement and a length of 212.9 meters. Moreover, she was designed to carry 4000 to 15,000 passengers, and to reach an unprecedented speed of 20 knots.[58] In order to realize how enormous Brunel's project really was, we should remember that the famous *Titanic* of 1912, which was one of the largest steamships ever constructed, could carry only 2200 passengers and was 252 meters long. Brunel's design, thus, was truly revolutionary in its size. Many contemporary observers and modern historians attributed the size of the ship entirely to Brunel's' megalomania. For example, Alfred Holt in 1877 said: " Considering Mr. Brunel's genius and the flow of capital, the only wonder was that she was so small."[59] Indeed, Brunel's quest for grandeur had some effect on all his projects, but a point to emphasize is that the gigantic size of the *Great Eastern* had practical applications and was intended to be a solution for a number of problems.

The problems that Brunel hoped to solve through the gigantic design of his final ship were threefold. First, the ship had to be large enough to carry coal to travel to Australia and back to England without refueling.[60] The ship was designed "to carry entire colonies of emigrants who were going to seek fortunes in Australia."[61] As Brunel indicated in his notebook, "Nothing is proposed but to build a vessel of the size required to carry her own coals on the voyage."[62] Brunel calculated that to achieve this aim, the ship would require a huge carrying capacity of roughly 15,000 tons, as she would consume about 300 tons of coal a day.[63] Such calculations right, from the start, eliminated any wooden design. Moreover, to move this vessel halfway around the world and back with a human cargo of 4000 passengers on board, the ship required more power, durability and size than any existing naval deign could provide. All these factors, rather than Brunel's megalomania, called for a radical new and untested design. As Brunel indicated in 1853 letter to Scott Russell,

> The wisest and safest plan in striking out a new path is to go straight in the direction we believe to be right, disregarding the small impedimenta which may appear to be in our way-to design everything in the first instance for the best possible results… and without yielding in the least to any prejudices now existing… or any fear of consequences.[64]

Hence, Brunel was confident that a new and radical design, with independent propulsion systems, screw, side wheels and sails, was necessary in order to build an improved steamer and open new horizons for steam navigation.

Second, Brunel wanted to make the vessel more durable and safer than other vessels, reasoning that a larger ship would be harder to sink than a small wooden craft.[65] Moreover, to increase the ship's safety, he introduced a cellular bottom, double shell, watertight doors, watertight longitudinal and transverse bulkheads up to the top deck, and other innovations that proved their worth, as the *Great Eastern* was exposed both to internal and substantial external underwater damage, each time staying afloat.[66]

The last major problem that Brunel hoped to solve through his design was to create a ship so enormous and self-sufficient that it would eliminate any foreign competition and dominate both the Indian and the growing Australian trade [67] and, at the same time, firmly establish Great Britain's domination of merchant shipping. The enormous ship, he argued, would eliminate competition and thus would be much more financially successful than any existing fleet of small crafts,[68] as he indicated in his diary:

"Vessels much larger than have been previously built could be navigated with great advantage from the mere effect of size".[69]

With these arguments at hand, in 1852, and with help of Scott Russell, who with James Watt's corporation was later to supply the gigantic steam engines that would power Brunel's grand vision, Brunel proposed his project for the 'great ship' to the directors of the Eastern Steam Navigation Company.[70] In 1854, the contracts were signed, the keel was laid, and the *Leviathan* was born. [71] By the time Brunel began working on his grand ship, he already built twenty-five railroads; eight dry docks; five suspension bridges; 125 railroad bridges; and two famous ships, the *Great Western* and the largest ship in the world at that time, the *Great Britain.*[72] His quest to push the limits of technology and human ingenuity culminated in his building of the *Great Eastern*. Although the ship had already been named by Brunel and Russell as the *Leviathan*, the Eastern Steamship Company, which bought the design, renamed her, in

1857,[73] as the *Great Eastern*.[74] In 1855, the world had its first glimpse of the monster. Correspondent for the Paris Exhibition reported:

> If you desire to take a leap forward into the future, in order to ascertain what wonders it is preparing for us, your wish will be gratified beyond expectation by the model of John Scott Russell's Leviathan ship… with photographs displaying the actual progress of the works, thus proving that this locomotive sea city is no fiction, but a project in process of realization.[75]

The construction and the aftermath of building the *Great Eastern* from 1857 until her inglorious end, when she was sold for scrap in 1889, is the primary concern of this paper. For this reason, the second chapter will examine the political, social and economical events that led to the design and construction of the *Great Eastern* from 1851-1857, as well as Brunel's and his father's engineering backgrounds. The second chapter will also discuss the role of Scott Russell in the project, and the long process of bringing the human, financial and technological resources together, in order to move this gigantic project from the drawing boards to reality. The third chapter will explore in detail the actual construction of the ship in the years 1857-1859, including her long launching process, and will end with the floating of the *Great Eastern*'s hull, and the collapse (from a stroke) of Brunel. The fourth chapter will explore the aftermath of the ship's construction, her career from 1859 until 1888, and her misfortunes at sea. This chapter will also examine in detail all of the ship's various owners and their inability to manage the gigantic vessel. The last, fifth chapter (the conclusions), will discuss the end of the great ship in 1889 and will demonstrate why her design should be regarded as a success rather than failure, as well as what influence she had on further maritime development.

The nineteen-century was a unique time in human history when technology was seen as the only solution to many problems,[76] few questioned the concept of achieving progress at any cost,[77] and almost anything seemed possible. In those years of industrial expansion and unprecedented triumphs of technology and engineering, Brunel attempted to build a sea-monster, the *Leviathan*:

> The engineers were running the world. The capitalists eagerly tried to keep up with their blueprints. The common people were prepared to go anywhere with the golden engineers. Royalty deferred to them. The applied mechanical mind would conquer everything. The Exhibition [1851] was the cachet of machine age genius. In this triumphant hour, Brunel and John Scott Russell entered the tragic climax of their lives. They determined to build the iron Leviathan.[78]

Notes

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[1] Peter Kemp, Encyclopedia of Ships and Seafaring (London: Stanford Maritime, 1980), p. 85.

[2] Vernon Gibbs, Passenger Liners of the Western Ocean (London: Staples Press, 1957), pp. 37-52.

[3] John Guthrie, Bizarre Ships of The Nineteenth Century (South Brunswick: A. S. Barnes, 1970), p. 123.

[4] James Dugan, The Great Iron Ship (New York: Harper, 1953), p. 132.

[5] Peter Kemp, Encyclopedia of Ships and Seafaring (London: Stanford Maritime, 1980), p. 86.

[6] Courtlandt Canby, A History of Ships and Seafaring (New York : Hawthorn Books, 1963), p. 95.

[7] Except for the last ones, but they bought the ship not to use her as a sea vessel but for scrap.

[8] Scientific American "The Great Eastern Mowing to Her Last Berth", Vol. 59, October 13, 1888, p. 226.

[9] Scientific American, "The End of the Great Eastern", Vol. 59, September 29, 1888, p. 226.

[10] J. Barnard Walker, Scientific American, "The Unsinkable Ship", Vol. 83, May 11, 1912, p.417.

[11] London Illustrated, "The Great Eastern Steamship" No. 987, Vol. XXXV, Saturday, August 13, 1859, p. 160.

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[12] London Illustrated, "The Great Eastern Steamship" No. 987, Vol. XXXV, Saturday, August, 13, 1859, p. 160.

[13] The Times, "The Paris Universal Exhibition", Issue 22180, Tuesday, Oct 09, 1855, p.7.

[14] John Guthrie, Bizarre Ships of The Nineteenth Century (South Brunswick: A. S. Barnes, 1970), p. 123.

[15] Peter Kemp, Encyclopedia of Ships and Seafaring (London: Stanford Maritime, 1980), p. 86.

[16] James Dugan, The Great Iron Ship (New York: Harper, 1953), p. 34-35.

[17] James Dugan, The Great Iron Ship, p. 267.

[18] James Dugan, The Great Iron Ship, p. 132.

[19] Crosbie Smith, Ian Higginson, and Philip Wolstenholme, Avoiding Equally Extravagance and Parsimony (The Society for the History of Technology, 2003), p. 462.

[20] K.O. Borchardt, Znaczy Kapitan (Gdansk: Wydawnictwo Morskie, 1977), pp. 5-135.

[21] Richard Gould, Archaeology and The Social History of Ships (New York: Cambridge University Press, 2000), p.238.

[22] Elis Karlsson, Ostatnie Zaglowce (Gdansk: Wydawnictwo Morskie, 1974), p 11.

[23] Georg Kahre, The Last Tall Ships: Gustaf Erikson and the Aland Sailing Fleets (New York: Mayflower Books, 1978), pp. 16-20.

[24] Elis Karlsson, Ostatnie Zaglowce (Gdansk: Wydawnictwo Morskie, 1974), p 11.

[25] Georg Kahre, The Last Tall Ships: Gustaf Erikson and the Aland Sailing Fleets (New York: Mayflower Books, 1978), p. 192.

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[26] Jerzy Micinski, Archiwum Neptuna (Warszawa: Wdawnictwo Ministerstwa Obrony Narodowej, 1957), pp. 72-75.

[27] Philip McCutchan, The Golden Age of Sail (London: Weidnefeld and Nicolson, 1976), p.8

[28] She remains the largest sail ship in the world. Paul Bishop, Tall Ships and the Cutty Sark Races (Warsaw: Alma Press, 1996), p. 122.

[29] Georg Kahre, The Last Tall Ships: Gustaf Erikson and the Aland Sailing Fleets (New York: Mayflower Books, 1978), p. 195.

[30] Clippers, for example, such as the *Ariel* and *Taeping,* reached a speed of 17 knots and sailed with an average speed of 10 knots per hour. Jerzy Micinski, Archiwum Neptuna (Warszawa: Wdawnictwo Ministerstwa Obrony Narodowej, 1957), p. 64.

[31] Basil Greenhill, The Life and Death of the Merchant Sailing Ship (London: W.S. Cowell, 1980), p. 3.

[32] Björn Landström, The Ship, An Illustrated History (Garden City, N.Y: Doubleday, 1961), p. 230.

[33] Peter Kemp, Encyclopedia of Ships and Seafaring (London: Stanford Maritime, 1980), p. 85.

[34] L.T.C. Rolt, Isambard Kingdom Brunel (London: Longmans, 1957), p. 197.

[35] John, Pundney Brunel and His World (London: Thames and Hudson, 1974), p. 77.

[36] Vernon Gibbs, Passenger Liners of the Western Ocean (London: Staples Press, 1957), p. 35.

[37] L.T.C. Rolt, Isambard Kingdom Brunel, p. 193.

[38] L.T.C. Rolt, Isambard Kingdom Brunel, p. 194.

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[39] Robert G. Albion, Five Centuries of Famous Ships : From The Santa Maria to The Glomar Explorer (New York : McGraw-Hill, 1978), p. 168.

[40] Derrick Beckett, Brunel's Britain (Newton Abbot: David and Charles, 1980), p. 170.

[41] John, Pundney Brunel and His World (London: Thames and Hudson, 1974),p. 80.

[42] Robert G. Albion, Five Centuries of Famous Ships : From The Santa Maria to The Glomar Explorer (New York : McGraw-Hill, 1978), p. 167.

[43] John Pundney, Brunel and His World, p. 80.

[44] John Pundney, Brunel and His World, p. 80.

[45] Peter Hay, Brunel-His Achievements in the Transportation Revolution (Berkshire: Osprey, 1973), p. 66.

[46] Quoted by John Pundney in Brunel and His World, p. 80.

[47] John Pundney, Brunel and His World, p. 81.

[48] John Pundney, Brunel and His World, p. 81.

[49] L.T.C. Rolt, Isambard Kingdom Brunel, p. 199.

[50] Is worth noting that most of the secondary sources are actually incorrect ,for although it is true that the *Great Western* arrived in New York only hours after the *Sirius* on the same day, April 23, in fact, the *Sirius* arrived in America on the April 22, thus one day before the *Great Western*. However, she entered New-York's harbour on April 23.

[51] L.T.C. Rolt, Isambard Kingdom Brunel, p.197.

[52] Ewan Corlett, The Revolution in Merchant Shipping (London: H.M.S.O., 1981), p.5.

[53] Peter Kemp, Encyclopedia of Ships and Seafaring (London: Stanford Maritime, 1980), p. 85.

[54] John, Pundney Brunel and His World, p. 88.

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[55] She stayed afloat until the 1970's when she was placed in a dry-dock and restored to her former glory, as an everlasting monument to Brunel and other Victorian-age engineers.

[56] The first calculations and the drawings of the ship were recorded in Brunel's notebook in around 1851; the ship that Brunel designed, however, differed greatly from the later designs influenced by Scott Russell.

[57] A.T. Mahan, From Sail to Steam (New York: Harper, 1907), p.3.

[58] 1 knot = 0,514m/s that is 1850.4 m per hour; thus 1 knot = 1.85km/h; thus, 20knots = 37km/h. Equation taken from Z. Grabowski, Tysac Slow o Morzu i Okrecie (Warszawa: Ministerstwo Obrony Narodowej, 1955), p. 212.

[59] Crosbie Smith, Ian Higginson, and Philip Wolstenholme, Avoiding Equally Extravagance and Parsimony (The Society for the History of Technology, 2003), p. 462.

[60] John, Pundney Brunel and His World, p. 77.

[61] Scientific American-Supplement, "The Great Eastern", No 672, vol. 26,November 17, 1888, p. 10734.

[62] James Dugan, The Great Iron Ship, p.5.

[63] L.T.C. Rolt, Isambard Kingdom Brunel, p. 237.

[64] Quoted by L.T.C. Rolt, Isambard Kingdom Brunel, p. 240.

[65] L.T.C. Rolt, Isambard Kingdom Brunel, p. 238.

[66] The immense internal explosion on her trials, and the 80-foot-long hole ripped in her bottom as she was steaming for New York, are the most notable of her countless misfortunes.

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[67] The Atlantic crossing was not what Brunel originally had in mind, for he designed the ship to travel to Australia and India rather than to America.

[68] L.T.C. Rolt, Isambard Kingdom Brunel, p. 238.

[69] James Dugan, The Great Iron Ship, p.5.

[70] Peter Kemp, Encyclopedia of Ships and Seafaring, p. 86.

[71] The first idea of the 'great ship' was formed shortly after the Great Exhibition of 1851, when Brunel for the first time discussed the matter with Russell, who believed in the grand project from the start.

[72] Peter Kemp, Encyclopedia of Ships and Seafaring (London: Stanford Maritime, 1980), p. 86.

[73] Primary sources (the *Times*) indicate that the name *Great Eastern* was used for the first time in January of 1857. The Times, "The Great Eastern Monster Ship", Issue 22574, Saturday, Jan 10, 1857, p.7. Previously the ship was always referred to as the *Leviathan*, and in the *London Illustrated,* it retained this name until 1859.

[74] Peter Kemp, Encyclopedia of Ships and Seafaring (London: Stanford Maritime, 1980), p. 86.

[75] The Times, "The Paris Universal Exhibition", Issue 22180, Tuesday, Oct 09, 1855, p.7.

[76] Samuel Florman, The Existential Pleasures of Engineering (New York: St. Martin's Press, 1976), p. 6.

[77] Except for Luddites and other machine-breakers, as Alan Brooke, in Liberty or Death: Radical Republicans and Luddites (Honley: Workers History Publications, 1993), and

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Angela Bull, in The Machine Breakers: The Story of the Luddites (London: Collins, 1980) indicated.

[78] James Dugan, The Great Iron Ship, p. 33.

Chapter 2

The Father and Son

Isambard Kingdom Brunel was born on the 9th of April 1806, [1] at Portsea, England,[2]and his family originated from Normandy.[3] His father, Marc Isambard Brunel, first served in the French navy, and later, in 1793 he left for New York to seek a better life. By 1796, he was appointed the chief engineer of New York, but in January of 1799, he resigned this position and left for England to marry Sophie Kingdom on November 1, 1799.[4] Ever since his first appointment in 1796, Marc Brunel was interested in improving shipyards, and he was working on the use of machines to improve the efficiency of the shipbuilding technologies.[5] In 1800, he proposed plans for the use of machinery to solve the British Navy's block-supply problems. Before his machines were introduced, ship-blocks were made by hand. Since the blocks were a crucial component of a sail ship's construction, for they were used for operating the sails, they were always in a high demand. In 1801, Marc made a model of his woodworking machinery, which was designed to make possible the industrial production of the ship-blocks. In 1802, the Navy accepted his invention, and Marc Brunel was put in charge of the machine's installation at Portsmouth dockyards. With such success and money to invest, he opened his own sawmill and veneer factory on the banks of Battersea River in 1807.[6] When he became aware of problems with the Army's boot supplies and quality, Marc, seeking possible profits, designed and built new machinery for boot production. Although his success was immediate and he was a very prosperous man by 1812, a fire at his factory in 1814 caused a great decline in his family's fortunes. Moreover, the end of war with France in 1815 terminated demand for the boots that he had already produced.

Despite these problems, he managed to send young Isambard to Hove, to attend a boarding school run by Dr. Morell.[7] In a letter to his father, at age of fourteen, Isambard wrote: "I have been making half a dozen boats lately, till I have worn my hands to pieces. I have also taken a plan of Hove, which is very amusing job."[8] This letter indicates that Isambard Brunel was interested in shipbuilding and designing from a very young age and had some talent for engineering. In November of 1820, Isambard was sent to college at Caen (Normandy) and in 1821, to the prestigious school of mathematics, the *Lycée Henri Quatre* in Paris.[9] However, a fire in 1814 at the Battersea sawmill, and dishonest partners ruined his father, and Marc Brunel and his wife were placed in debtor's prison at Southwark in May 1821. After three months in prison, they were released. With the help of his family and friends, Isambard was able to finish his education in France, and in August 1822, he returned to England to gain practical experience with his father. In the same year, 1822, Marc rented a small office in London, working as a consultant engineer and a designer. Isambard was then sixteen and worked with his father, gaining engineering experience. Marc managed to get some government contracts to design sawmills for Chatham, Woolwich, Trinidad and two suspension bridges. [10] These bridge designs had, later on, an important impact on young Brunel's career.[11] The break-through in the Brunel's family misfortunes, and engineering glory and fame, finally came to Isambard and Marc with the designing and building of the Thames Tunnel.

Marc Brunel first pondered the project in 1817 when the Tsar of Russia asked him to solve the transportation problems over the River Neva in St. Petersburg.[12] At that time, however, he rejected the idea of tunneling under a river, mainly because such attempt had never succeeded before. The first tunnel under the Thames River was undertaken by Robert Vazie around 1806 and then carried on by the famous engineer Richard Trevithick. By 1807, Trevithick seems to have managed to dig a complete tunnel under the river, but water leaking through the roof ended the project in the same year.[13] This early unsuccessful attempt provided vital information for Brunel about the strata beneath the riverbed.

London traffic was rapidly increasing in the early 1800's, and the medieval London Bridge was proving inadequate for moving the growing number of people and increasing amount of cargo across the river. Consequently, in 1823, Marc Brunel considered the possibility of building a tunnel to solve this problem,[14] and he proposed his project to a provisional committee, which presented the proposal before the public. In July 1824, the design was accepted by the Parliament, and the Thames Tunnel Company was established with £160,000 of capital.[15] Marc was appointed the chief engineer of the entire operation.

Two major engineering obstacles had to be overcome before the work could proceed. First, Marc had to devise an invention that would allow for working under the river in safe conditions. Timber, which had been used previously to hold the immense weight of sand, water and clay, was insufficient to support the walls and ceiling of Brunel's project. The tunnel was to be wide enough to admit two-way wheeled traffic. The solution to this problem, as most historians have mentioned,[16] Brunel obtained by observing nature. The story goes that while he was examining some kind of wood-eating beetle, he came up with an invention he called a 'shield', which was patented in 1818.[17] The device used hydraulic rams to support the weight above and to push forward while the manual laborers dug the tunnel, by hand, inside an iron frame.[18] The second problem that Marc had to solve was the digging of a shaft over 24 meters deep, without having the water coming through the sides. Such depth was necessary in order to reach the dry layers beneath the Thames and to start the tunnel. To overcome this engineering obstacle, he proposed prefabricating the shaft and placing it so it would stick above the surface and move down on its own weight while the gravel was removed from underneath the shaft's sides. The idea worked, and in March 1825, the first brick for the tunnel was laid.[19]

Young Isambard was working with his father almost every day and committed himself to this engineering adventure, as his father's journal of 1825 indicated: "Isambard incessantly in the works, most actively employed, shows much intelligence.... Isambard was in the frames the whole night and day.... Isambard has been every night and day too in the works."[20]

By April 1827, the site of the tunnel's construction became a public attraction: tickets were sold, and some 700 visitors came each day. Marc was alarmed by so many of 'tourists' coming into an active construction site and recommended that the tunnel should be closed to the public. He wrote in his journal: "Notwithstanding every prudence on our part, a disaster may still occur. May it not be when the arch is full of visitors! It is too awful to think of it. I have done my part by recommending to the directors to shut the tunnel."[21] Five days later, on May 18th, 1827,[22] he wrote: "The water increased very much at 9 o'clock.... My apprehensions are not groundless. I apprehend nothing, however, as to the safety of the men."[23] This concern, however, did not stop him from sending his son Isambard and 161men into the tunnel on the same day.

Marc's fears were realized when, in the evening, the river broke into the tunnel. His son, being amongst the men underground, managed to rescue one of the workers, an old engine man named Taillett,[24] and by his (Isambard's) orders, saved the rest of the men. Next day, Isambard, using a diving bell, inspected the riverbed and discovered a deep depression on the bottom. The hole had been formed artificially by the gradual extraction of gravel from the river. By June 1827, the workers had covered it with clay-filled bags, and the gap in the tunnel was sealed.[25] In order to inspect the flooded tunnel, Isambard Brunel, some miners, and the directors of the Thames Tunnel Company took a boat ride underground. The boat capsized, and one person was drowned.[26] This misfortune caused Marc Brunel to resign from his position, and in August, he handed over the supervision of the tunnel to Isambard. At the age of 21, he became the principle engineer on a major project.[27]

The work resumed in August, but many problems occurred, mainly with ventilation and lighting. These problems caused several injuries and slowed down the entire enterprise. Everyone was also sick because of the gas poison, which was utilized for the lighting, and the produced CO_2. On January 14, 1828, the tunnel collapsed again. This time, Brunel was seriously injured, and six men lost their lives. Brunel described the event in his formal report to the directors:

> ...I was at that moment [of the collapse] giving directions to the three men what manner they ought to proceed in the dark to effect their escape, when they and I

> were knocked down and covered by a part of the timber stage. I struggled under water for some time and at length extricated myself from the stage.... My knee was so injured by the timber stage that I could scarcely swim or get up the stairs, but the rush of water carried me up the shaft. The three men who had been knocked down with me were unable to extricate themselves, and I grieve to say that they were lost; also two old men and one young man in other parts of the work.[28]

The accident caused internal injuries to Brunel and consequently forced him to lie for a long time "useless" in bed: " I have now been laid up quite useless for 14 weeks and upwards, ever since 14th January. I shan't forget that day in a hurry, very near finished my journey then...."[29] The accident also halted the tunnel building for seven years and ruined the company financially. Consequently, in August, Marc Brunel resigned, while Isambard was sent to Brighton for convalescence. The work was restarted in 1835 when Brunel received a loan from the government. Although the river broke into the tunnel three more times, it was finished on November 16, 1841, and in March, Marc Brunel was knighted.[30] He died on the 12th of December 1849 in his 81st year.[31] On March 25, 1843, the tunnel was opened to the public, and since 1869, it has been a route for railway traffic.

Isambard Brunel's next engineering projects were bridge and railway constructions. After being moved from Brighton to Clifton for further convalescence, he learned about a contest for a Clifton bridge to connect two parts of the Avon Gorge, which carried water traffic to and from Bristol. Brunel's knowledge of suspension bridge designs proved to be essential to his success. An open competition resulted in twenty-two plans being submitted, four of them coming from Brunel. Five, including one of Brunel's, were chosen for serious consideration. A part of the finances for the bridge came from William Vick, who, in 1753, had left money for building a stone bridge across the gorge.[32] By 1829, £8000 had been collected for this purpose, and the contest for best design was opened.[33] Brunel proposed to build a suspension bridge, but its length would exceed that of any existing design and thus was rejected by Thomas Telford, the most celebrated bridge builder at that time.

In October of 1830, a new competition was opened, and Telford proposed his own gigantic stone bridge design, which was rejected as being too expensive,[34] while Brunel proposed a design for a shorter 700- foot suspension bridge finished in an Egyptian style. This design was accepted since its appearance greatly appealed to the committee and the Bristol residents, as Brunel explained: " The Egyptian thing I brought down was quite extravagantly admired by all and unanimously adopted." [35] The estimated cost of the bridge was £40,000, but the funds were insufficient, and while Brunel was alive, only the two gigantic bridge piers were completed. The entire bridge was not finished until 1864, when it was completed by a group of Brunel's friends who "had an interest in the work as completing a monument to their late friend Brunel."[36] Meanwhile, the city of Bristol was experiencing some serious crises. Its rival as a major port in Britain, Liverpool, was being equipped with wet-docks and from 1830, was connected by George Stephenson's Liverpool and Manchester Railway with other cities. This situation created a demand for a Bristol-to-London railway. In March 1833, Brunel was offered a position in the project as a surveyor. Eventually, the project become known as the Great Western Railway.

The task was immense, and Brunel's journal from that time indicates that he worked some twenty hours a day and found the job much more harder than he had anticipated.[37] However, as he had contracted to do, he finished the work on time in

May 1833 and estimated the total cost of the enterprise at £2,800,000. The detailed survey that followed cost some £300,000. It was needed before the bill for the railway could be presented to Parliament. The survey however, resulted in a strong objection from the landowners who lived near the proposed railway and feared the devaluation of their land and the destruction of the scenery.[38] Consequently, Parliament rejected the bill when it was first introduced. It was, however, passed in September 1835 when it was introduced for the second time with the strong support of George Stephenson and other important figures.[39] The work began immediately and simultaneously in Bristol and London. Young Brunel was hired as the project's chief engineer with a salary of £2000 a year.[40] He was fully successful, and his diary reflects his joy:

> When I last wrote in this book I was just emerging from obscurity. I had been toiling most unprofitably at numerous things – unprofitably at least at the moment. The Railway certainly was brightening but still very uncertain-what a change. The Railway now is in progress. I am their Engineer to the finest work in England – a handsome salary – £2000 a year – on excellent terms with my Directors and all going smoothly, but what a fight we have had [in order to pass the bill]– and how near defeat – and what a ruinous defeat it would have been. It is like looking back upon a fearful pass – but we have succeeded. And it's not this alone but everything I have been engaged in has been successful.[41]

After the opening of the Thames Tunnel and the Great Western Railway Isambard and his father became respected engineers.[42] Isambard was well known by the upper classes and admired by the general public.[43] Because of his status, he served on committees connected with the Great Exhibition of 1851. During these meetings, he met Scott Russell, a Fellow of the Royal Society and Vice-President of the Institute of Naval Architects and Civil Engineering.[44] Russell was a marine engineer and an owner of a shipyard at Millwall on the Isle of Dogs. The Great Exhibition of 1851, during which they met, was also the crucial event that in many ways resulted in the building of the *Great Eastern*.

The Great Exhibition was in its size and grandeur and display of industries an unprecedented event, as reporters indicated: "The journals which report the proceedings at the Crystal Palace have perhaps, a difficult task to convey to the most distant parts of the world a full, true, and particular account of the wonders of art and industry exhibited within…"[45] The construction of the Crystal Place was in itself an engineering triumph carried out on a scale unseen before. The Great Exhibition also displayed the wealth and wonders of colonial Britain. This display, combined with discovery of gold in Australia in 1851, created a sudden wave of emigration to the antipodes. Consequently, the shipping trade to Australia grew rapidly after 1851. No iron-hull steamship existed that could sail half way around the world, and the only alternative, the wooden sail ships, were proving increasingly inadequate and unsafe for this long voyage. As an underwater archeologist, Richard Gould, indicated, the iron ships had many advantages over the wooden ones:

> [The iron steam-sail ships] had greater cargo capacity (from 14 to 18.6 percent more in the case of oak hulls to 21.5 percent more in the case of fir hulls in ships of the same registered dimensions) because of the greater strength of iron construction. Iron hulls also required less upkeep and lasted longer than wooden ones, further contributing to their profitability, and they were less susceptible to fire.[46]

The iron-made hulls were also much safer than those of the wooden ships and thus were preferred by the shipbuilders, especially in Britain.[47] The contemporary sources indicate the large amounts of cargo and people lost during that period due to strong winds and violent storms.[48] For these reasons and the increasing shortage of suitable trees, iron, although much more expensive, eventually replaced wood as the primary ship-building material.

The growing wave of emigration to Australia caused an immediate demand for the use of Brunel's iron-steamship the *Great Britain*, which was the biggest ship at that time. In the same year, 1851, she was chartered by Gibbs, Bright and Company, but, unable to carry all of her own fuel from England to Australia, she had to refuel, on both her way to Australia and on her return trip to England.[49] The Gibbs, Bright and Company charted another ship, which served as a coalbunker and sailed from Penarth to supply the *Great Britain* with fuel. Such an arrangement proved to be extremely expensive, to the point that the shipping companies decided to consider a proposal for a ship that could carry its own load of fuel from England to Australia.

It is difficult to pin down exactly when Brunel envisioned his gigantic ship, but the drawings indicate that in about 1851[50], he made the first sketch of it. However, he did not discuss the matter until late 1851 or early 1852.[51] In 1851, the Australian Mail Company asked Brunel to consider the optimal design of a ship for the Australian service.[52] Brunel designed two huge ships of 5000 and 6000 tons, but both would require one refueling. The two ships, named *Victoria* and *Adelaide*, were built in 1852 under Brunel's directions, in Scott Russell's shipyard at Millwall.[53] The building of these two ships, combined with the growing emigration to Australia, after the Great Exhibition, seems to have convinced Brunel that a ship twice as large would solve the problem of expensive overseas bunkering stations. Moreover, he argued that a ship of such a size would be superior in speed and thus cheaper to operate, for the crew's wages, due to a shorter time at sea, could be reduced, while at the same time, one ship would be far less expensive to maintain than two.[54] These arguments led him to conclude that a ship six times larger than anything afloat would be even more efficient and financially successful. This conclusion clearly reinforces the point that the size of Brunel's grand ship had a real practical purpose, rather than resulting from his megalomania.

His idea was too revolutionary for the Australian Mail Company, which did not approve Brunel's plans for the monster ship. In the spring of 1852, Brunel discussed his proposal with Claxton and Scott Russell.[55] Both became strong supporters of the project, and in the same year, the idea was mentioned to Henry Thomas Hope, director of the Eastern Steam Navigation Company, which since 1851, had been interested in opening a passenger-mail steamer route to India, China and Australia.[56] In March of 1852, the British government granted the mail contract for this route to a rival party, the Peninsular and Oriental Steam Navigation Company.[57] After such a defeat, the directors of the Eastern Steam Navigation Company were in desperate search for a plan that could bring them back the lost business. Brunel proposed a monster-ship, which, in theory, could eliminate any competition and dominate once and for all the Australian and the Eastern seaways, while simultaneously being operated at minimal cost. The speed with which the decisions were made indicates that the project was everything that the Eastern Steam Navigation Company was hoping for. In a matter of months, by July 1852, all this company's directors had approved Brunel's proposal.[58] It was also decided that the hull would be built at Scott Russell's shipyard at Millwall and that Scott Russell and James Watt and Company would supply the ship's steam engines.

The Russell's shipyard, however, was in no way prepared or an adequate site to accommodate such a gigantic project. Only one historian has correctly determinated that most of the work on the *Great Eastern* was, in fact, carried out not in Russell's shipyard, but in the Napier Yard, which was nearby.[59] This yard belonged to David Napier and had been opened in 1837. By 1853, it was deserted and leased by the Eastern Steam Navigation Company. A railway was built to connect the two shipyards, and parts of the ship, mainly the engines, were built at Russell's yard, while the actual site of the building and launching of the *Great Eastern* was at Napier's yard.[60] By December 1853, Russell's contracts were signed, obliging him to construct, launch, test and deliver the gigantic ship, while Brunel was appointed as the chief engineer of the enterprise. However, due to personal disagreements about the issuing of the contracts, the project did not start until 1854, as Brunel indicated in his diary: "After two years' exertions we are thus set going, contracts entered into work commenced February 25th 1854."[61]

Brunel estimated that the ship would cost £500,000[62] while Russell optimistically calculated its cost as follows: hull £275,200, screw engines and boilers £60,000, paddle engines and boilers £42,000, for a total of £377,200.[63] Both calculations proved to be drastically incorrect as the total cost of the ship, mainly due to Russell's errors, was about £1,600.000.[64] The further disagreements between Russell and Brunel resulted in bitter relations between the two and overshadowed the future of the ship.

The second major dispute emerged over the issue of launching the *Great Eastern*.

Russell and the company proposed to launch and build her on an end-on slip, for such a layout would eliminate the need for any additional force, as the ship would slide on her own from the inclined slip. (This process was known as the free end-on launch.) Brunel refused such a layout, calculating that one part of the ship would be forty feet in the air during the building process. This problem, Brunel argued, would make the work on the hull extremely difficult and almost impossible since the engines and the boilers were to be installed before the floating of the vessel.[65] Russell then proposed to built the ship in a dry-dock, whose cost he estimated at £8,000.[66] Brunel rejected the unrealistically low estimate for a structure that had never before been attempted on such an enormous scale. He also determinated that no safe area for such construction was available near the shipyard.[67] Russell, however, still insisted on a free end-on launch while Brunel, foreseeing the troubles that later doomed the ship's success, argued for a controlled sideways launch. For this purpose, he designed a mechanical slip, based on wheels, rollers, and steam presses that would lower the ship into the water on the tide and that later could be reused for the maintenance of the ship.[68] Russell insisted that such a device and the controlled launch would be too expensive and were not included in the terms of his contract, so he persuaded the directors of the company to refuse Brunel's proposal. This decision, later on, proved to be a fatal error when the vessel, as Brunel had predicted, was stuck on dry land, unable to move.

Meanwhile, the Napier Yard was being prepared for the future free sideways launch of the ship. For this purpose, some 1200 tons of timber were used, and the area was piled with 30 cm. to 38 cm. square oak piles from 6 meters to 11metters long, driven 1.5 meters apart.[69] The tops of these piles stood over 1 meter above the ground, and were the future support for the ship's hull. On May 29th 1854, the work at Napier Yard was completed.[70] The actual work on the ship, however, was facing serious problems. Although Brunel had given up on his mechanical slip design, and it had been decided, much to his dissatisfaction, that the ship would be launched without it, the work was proceeding very slowly. On July 9, 1854, Russell wrote to Brunel: "The keel has been laid and the whole of the plans of the various additional works you have proposed are fully occupying our attention."[71] It is worth noting that Brunel's design eliminated the keel: consequently, the ship had a flat bottom, so what Russell described as a 'keel' was, most likely only a flat plate. Although the 'keel' had been laid, not much work had been done since then. In the following letter to Russell, written on April 24th ,1855[72], Brunel expressed his concern about the lack of progress:

> I begin to be quite alarmed at the state of your contract—four months are gone and I cannot say that even the designs are completed or even sufficiently settled to justify a single bit of work being proceeded with—we shall get into trouble.[73]

After receiving no reply, Brunel wrote another, less polite, letter to Russell on August 12th :

> I have tired gentle means first, I must now strengthen the dose a little. If you do not see with me the necessity of shaking off suddenly the drowsiness of sleep that is upon us… In fact, unless, as I say, on Monday next we are busy as ants at ten different places now untouched I give it up….[74]

Brunel did not "give it up," but by 1855 the situation was even worse. The free-sideway launch proved to be, as Brunel had foreseen, impossible. He was thus forced to devise a new plan to move the 12,000 tons of iron some 100 meters into the water. To do so, he needed precise specifications for the ship, especially its center of gravity and center of flotation. For these, he wrote to Russell on August 23rd:

> I feel it most essential to have these particulars at once and I am rather surprised to find you less anxious to possess precise knowledge on such points than I am —Experience may make you quite easy, you are wrong, I think — at all events I am not going to trust to chance and must satisfy myself at once on these points which will influence the arrangements to be made for launching.[75]

Russell instead sent him a demand for an additional £37,673, claiming that the changes which Brunel had made to the plan would require more capital. At this point, Brunel appears to have lost his patience, and his reply marks the definite end of any positive relations between him and Russell: "How the devil can you say that you satisfied yourself of the weight of the ship when the figures your Clerk gave you are 1000T less than I make it or than you made it a few months ago—for shame—if you are satisfied."[76]

The lengthy correspondence between Brunel and Russell is important, for it indicates some serious problems with the ship's building were occurring at the earliest stage of construction. It also suggests that the building of the *Great Eastern* was largely on the shoulders of one man, Brunel. Moreover, since Brunel supplied Russell with £292,295[77] of the company's money, which was only £40,000 less than the estimated sum for the entire finished and floated ship, and since the ship was far from being finished, Brunel took the blame for the state of construction.[78] Brunel seems to have truly trusted Russell, but this trust was abused on many occasions. As L.T.C Rolt stated: " The story of the *Great Eastern* was a tragedy of trust misplaced and betrayed."[79] Russell, as it turned out, took the money but did not pay for the iron nor did complete what he claimed he did. When Brunel finally came to the site and saw that almost nothing was finished, yet all the money had been spent, he demanded an immediate response from Russell and an explanation for his misinformation and his abuse of the company's funds. By 1856, Russell was refusing any cooperation, and although he had received almost the entire amount of the ship's estimated cost, the work did not proceed. The sum of £377,200 proved to be a complete miscalculation, and Russell, on paper, was badly in debt.[80] Consequently, in February 1856, the work on the grand ship was terminated.[81] Russell arrogantly refused to continue the work unless he received, from the Eastern Steam Navigation Company, an additional £15,000 a month.[82] Under such circumstances, on May 22, 1856, the company took over the project, and placed Brunel in charge of the entire operation. The work was resumed four days after Brunel took his new appointment,[83] and the ship began to take shape. One reporter indicated:

> At first a few enormous poles alone cut the sky-line and arrested his attention, then, vast plates of iron, that seemed big enough to form shields for the Gods, reared themselves edgeways at great distance apart, and as months elapsed, a wall of metal slowly rose between him and the horizon.[84]

The situation behind the scenes was, however, more complex. Brunel and his loyal friends invested large sums of money in the *Great Eastern* and were caught in a financial trap. They had no other choice but to finish the ship at any cost or lose their investments. Russell and his workers knew about Brunel's determination to finish the ship, and as a pamphlet by an unknown author from 1858 indicates, they took full advantage of the situation:

> Every one who had been connected with the previous operations [when Russell was in charge] refused to give their assistance except upon the most outrageous terms and for the most exorbitant salaries. There was nothing to do but to submit, for the foremen had the drawings and details of the working plans, they had been trained to the work and their places could only be supplied by men who had received a similar amount of training and experience.[85]

Such was the situation behind the scenes of the great ship's construction. The extremely high cost of the *Great Eastern* and the resulting financial disaster were caused mainly by Russell's mistakes rather than Brunel's megalomania, his quest for glory, or the ship's design. On the contrary, in those years, Brunel was working extremely hard, both physically and mentally, to get the ship finished as soon as possible. Once Russell was removed from the project and walked away claiming bankruptcy, Brunel's determination was the main factor that made the further construction of the ship possible. In the face of this evidence, which is rarely mentioned in the secondary sources, it is surprising that in June 1857, the ship was almost entirely finished:

> Poets, engineers, peoples and kings stood in common awe of the iron grandeur rising on the muddy strand of the London River. Americans were told that "the human intellect expanded at the sight." Two thousand workers scuttled like insects among the exorbitant parts of the ship....[86]

This chapter examined Brunel's and his father's engineering background, showing that Brunel had great and respected engineering knowledge before he attempted the design of his greatest ship. This knowledge, as it was argued, he gained from his father and the projects they worked on together. This chapter also examined the political, social and economical events, mainly the Great Exhibition, and the resulting emigration to Australia, that led to the design and construction of the *Great Eastern* from 1851-1857. This chapter also demonstrated that the *Great Eastern* project was well justified in economic terms and that her design was believed to be a solution to a number of problems, particularly those relating to the fuel supply and the growing demand for faster and more durable ships. The chapter also discussed the negative role of Scott Russell in the project, and this role's impact on the ship's future and Brunel's role in the enterprise, arguing that Brunel did most of the work on the ship and that his determination and hard physical and intellectual work made the construction of the ship possible.

Notes

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[1] Peter Hay, Brunel-His Achievements in the Transportation Revolution, p. 7.

[2] L.T.C. Rolt, Isambard Kingdom Brunel, p. 32.

[3] Peter Hay, Brunel-His Achievements in the Transportation Revolution, p. 2.

[4] Peter Hay, Brunel-His Achievements in the Transportation Revolution, p. 5.

[5] Peter Hay, Brunel-His Achievements in the Transportation Revolution, p. 6.

[6] Peter Hay, Brunel-His Achievements in the Transportation Revolution, p. 7.

[7] Peter Hay, Brunel-His Achievements in the Transportation Revolution, p. 7.

[8] John, Pundney Brunel and His World, p. 5.

[9] Peter Hay, Brunel-His Achievements in the Transportation Revolution, p. 8.

[10] Peter Hay, Brunel-His Achievements in the Transportation Revolution, p. 10.

[11] See p. 25 of the paper.

[12] Peter Hay, Brunel-His Achievements in the Transportation Revolution, p. 10.

[13] Peter Hay, Brunel-His Achievements in the Transportation Revolution, p. 11.

[14] Peter Hay, Brunel-His Achievements in the Transportation Revolution, p. 12.

[15] John Pundney, Brunel and His World, p. 13.

[16] Peter Hay, Brunel-His Achievements in the Transportation Revolution, p. 11.

[17] John Pundney, Brunel and His World, p. 12.

[18] John Pundney, Brunel and His World, p. 12.

[19] John Pundney, Brunel and His World, p. 13.

[20] Marc Brunel quoted by John Pundney in Brunel and His World, p. 14.

[21] Marc Brunel quoted by John Pundney in Brunel and His World, p. 15.

[22] Peter Hay, Brunel-His Achievements in the Transportation Revolution, p. 15.

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[23] John Pundney was incorrect in quoting Marc Brunel as writing these words two days before the disaster, in Brunel and His World p. 14, f or the entry in the journal was dated May 13 as, Paul Clements indicates in Marc Isambard Brunel (Harlow: Longmans, 1970), p. 143.

[24] Paul Clements, Marc Isambard Brunel, p. 145.

[25] Paul Clements, Marc Isambard Brunel, p. 147.

[26] John Pundney, Brunel and His World, p. 17.

[27] Paul Clements, Marc Isambard Brunel, p. 138.

[28] Brunel quoted by Peter Hay in Brunel-His Achievements in the Transportation Revolution, pp. 16-17.

[29] Brunel quoted by Peter Hay in Brunel-His Achievements in the Transportation Revolution, p 17.

[30] Peter Hay, Brunel-His Achievements in the Transportation Revolution, p. 18.

[31] Richard Beamish, Memoir of the life of Sir Marc Isambard Brunel (London: Longman and Roberts, 1862), p. 338.

[32] John Pundney, Brunel and His World, p. 24.

[33] Peter Hay, Brunel-His Achievements in the Transportation Revolution, p. 21.

[34] Peter Hay, Brunel-His Achievements in the Transportation Revolution, p. 22.

[35] Brunel, quoted by Peter Hay in Brunel-His Achievements in the Transportation Revolution, p. 23.

[36] John Pundney, Brunel and His World, p. 30.

[37] John Pundney, Brunel and His World, p. 35.

[38] John Pundney, Brunel and His World, p. 39.

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[39] John Pundney, Brunel and His World, pp. 41-42.

[40] John Pundney, Brunel and His World, p 43.

[41] Brunel quoted by John Pundney in Brunel and His World, p 43.

[42] Richard Beamish, Memoir of the life of Sir Marc Isambard Brunel, pp. I-IX.

[43] Sally Dugan, Men of Iron (London: Channel Four Books, 2003), pp 151-173.

[44] John Pundney, Brunel and His World, p. 90.

[45] London Illustrated, "The Great Exhibition" No. 488,Vol. XVIII, Saturday, May 24, 1851, p. 455.

[46] Richard Gould, Archaeology and The Social History of Ships (New York: Cambridge University Press, 2000), p. 243.

[47] In US, the wooden made ships were still dominant although they were also slowly being replaced by the iron ones.

[48] For the complete list of ships lost in that period, see Robert F. Marx, Shipwrecks in the Americas (New York: Dover Publications, 1987).

[49] L.T.C. Rolt, Isambard Kingdom Brunel, p. 237.

[50] However, a point to emphasize is that the earliest design of the vessel was much different from that of 1853.

[51] John Pundney, Brunel and His World, p. 91.

[52] L.T.C. Rolt, Isambard Kingdom Brunel, p. 237.

[53] L.T.C. Rolt, Isambard Kingdom Brunel, p. 237.

[54] L.T.C. Rolt, Isambard Kingdom Brunel, p. 238.

[55] L.T.C. Rolt, Isambard Kingdom Brunel, p. 238.

[56] L.T.C. Rolt, Isambard Kingdom Brunel, p. 238.

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[57] L.T.C. Rolt, Isambard Kingdom Brunel, p. 238.

[58] L.T.C. Rolt, Isambard Kingdom Brunel, pp. 238-239.

[59] L.T.C. Rolt, Isambard Kingdom Brunel, p. 246.

[60] L.T.C. Rolt, Isambard Kingdom Brunel, p. 247.

[61] Brunel quoted by L.T.C. Rolt in Isambard Kingdom Brunel, p. 239.

[62] John Pundney, Brunel and His World, p. 92.

[63] Brunel quoted by L.T.C. Rolt in Isambard Kingdom Brunel, p. 240.

[64] Scientific American-Supplement, "The Great Eastern", No 672, vol. 26,November 17, 1888, p. 10734.

[65] L.T.C. Rolt, Isambard Kingdom Brunel, p. 247.

[66] John Pundney, Brunel and His World, p. 92.

[67] L.T.C. Rolt, Isambard Kingdom Brunel, p. 247.

[68] John Pundney, Brunel and His World, p. 92.

[69] L.T.C. Rolt, Isambard Kingdom Brunel, p. 247.

[70] L.T.C. Rolt, Isambard Kingdom Brunel, p. 247.

[71] Quoted by L.T.C. Rolt in Isambard Kingdom Brunel, p. 248.

[72] L.T.C. Rolt, Isambard Kingdom Brunel, p. 253.

[73] John Pundney, Brunel and His World, p. 94.

[74] John Pundney, Brunel and His World, p. 94.

[75] L.T.C. Rolt, Isambard Kingdom Brunel, p. 253.

[76] L.T.C. Rolt, Isambard Kingdom Brunel, pp. 253-254.

[77] L.T.C. Rolt, Isambard Kingdom Brunel, p. 257.

[78] L.T.C. Rolt, Isambard Kingdom Brunel, p. 257.

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[79] L.T.C. Rolt, Isambard Kingdom Brunel, p. 15.

[80] L.T.C. Rolt, Isambard Kingdom Brunel, p. 258.

[81] L.T.C. Rolt, Isambard Kingdom Brunel, p. 258.

[82] John Pundney, Brunel and His World, p. 95.

[83] L.T.C. Rolt, Isambard Kingdom Brunel, p. 262.

[84] Quoted by John Pundney in Brunel and His World, p. 95.

[85] G. Vickers quoted by L.T.C. Rolt, Isambard Kingdom Brunel (London: Longmans, 1957), p. 262.

[86] James Dugan, The Great Iron Ship (New York: Harper, 1953), p. 1.

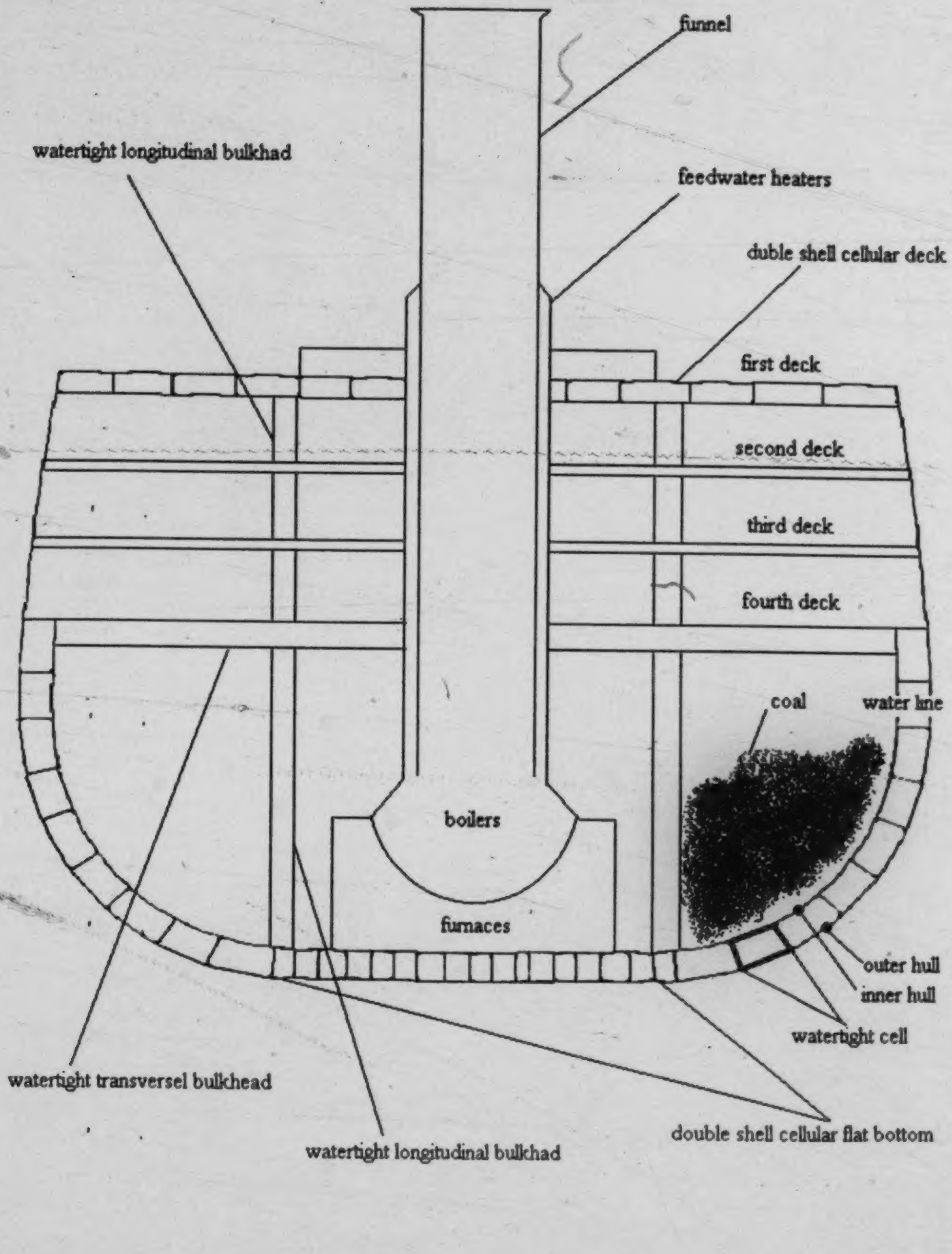
Chapter 3

The Birth of the *Leviathan*

After Brunel took command of the *Leviathan* construction, it was performed with great speed, and in September 1857, the last plates were riveted.[1] Some 2000 workers worked twelve hours a day, six days a week, to place over 3,000,000 rivets, which held the 30,000 metal plates that constituted the ship's hull.[2] Each section of the hull was prefabricated, and the hull's plates were shaped on wooden moulds before they were delivered to the construction site. This procedure was necessary, for the *Great Eastern* was to be the first ocean-going ship designed without ribs and based entirely on the use of longitudinal framing with transverse frames.[3] This design meant that instead of ribs being used for the support and shaping of the ship's hull, the ship's skin, to a large extent, was already shaped (prefabricated) and thus eliminated the use of ribs because it acted both as the ship's skin and the hull's frame. The plates were, moreover, connected to the longitudinal bulkheads, which served both as an additional support for the superstructure and as watertight compartments. They also served as the ship's decks and walls, for the bulkheads divided her vertically and horizontally [illustration 3]. Since the bulkheads were constructed of double iron shells, the empty space in between them acted as a watertight space. This revolutionary innovation by Brunel was later followed on all ocean liners, so that the modular construction of modern ships directly evolved from Brunel's 'rib-less' design.

The *Great Eastern*'s hull, in fact, consisted of two hulls, outer and inner, separated by a space of about 90 cm. Such a design, also later used for most ships,

Illustration 3. Transverse section through the *Great Eastern*.


funnel
watertight longitudinal bulkhad
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first deck
second deck
third deck
fourth deck
coal
water line
boilers
furnaces
outer hull
inner hull
watertight cell
watertight transversel bulkhead
double shell cellular flat bottom
watertight longitudinal bulkhad

made her almost unsinkable since the entire ship was protected by a double skin of iron that extended 160 cm above the waterline. Moreover, the ship's double skin was divided into a series of watertight cells and became known as the cellular bottom. This invention is still in use and mandatory on all ocean-going ships. Because of these innovations, any underwater damage would cause flooding of only the empty space between the two hulls within an individual damaged watertight cell, while the ship could stay afloat and sail to safety.

The longitudinal and transverse bulkheads, which divided the ship into 12 watertight compartments,[4] required a number of laborers to work in the dark 90 cm space in between the hulls. This unpleasant task was given to young boys, who placed and held a rivet while the workers outside hammered it until it was flat. During the construction of the *Great Eastern*, all three million rivets were driven by hand, making the task of construction extremely labor-intensive and also dangerous for the workers. Consequently, during the construction, the ship's first casualties occurred. Three workers died falling from the hull, one died inside the structure, one visitor was killed by a falling part of the ship, and two workers were reported missing.[5] One of the latter was believed to have been sealed alive inside the double hull, and supposedly, because of the hammering, no one could hear his screams for help. His skeleton was claimed to have been discovered during the breaking up of the ship, as David Duff, present at the site of the discovery, stated: "They [the breakers] fund a skeleton inside the ship's shell and the tank tops. It was the skeleton of the basher who was missing. Also the frame of the bash boy was found with him."[6] Although James Dugan in his book confirms this grim story,[7] we should take it with a bit of skepticism, for this account seems to be based on folk tales rather than any historical data, such as an official report, for example, or at least a news article. The primary sources give no indication of such a discovery.[8] However, the fact remains that officially, five men died and two were reported missing during the construction.[9] Although it might seem as a drastic figure, we should remember that the builders had every reason to be "proud of the low casualty rate,"[10] for the project was immense, and in those days, human casualties were considered to be normal during any construction project.[11] Thus, to the contemporaries of the great ship, the loss of 'only' five workers was, in fact, an indication of good working conditions.

While the hull was being finished, the work on the gigantic steam engines proceeded, which began as early as August 1854 at James Watt's factory at Birmingham.[12] The ship's screw engines were designed to give her 1600 horsepower, supplied by 6 boilers holding 270 tons of water, and 72 furnaces,[13] while her side-wheels' engines, weighting 836 tons, were to produce 1000 horsepower and have 4 boilers holding 160 tons of water, and 40 furnaces.[14] A crew of 200 men would be required to attend to the ship's engines at all time, as she would consume some 300 tons of coal a day.[15] Her screw engines were to consist of four cylinders, horizontally opposed, each 213 cm in diameter with a 122 cm stroke.[16] The side-wheels engines were also to use four cylinders with a stroke of 426 cm and a 188-cm bore. These gigantic cylinders were cast by Scott Russell and swallowed some 136 tons of iron, each cast consuming 34 tons.[17] At that time, no larger steam engine existed in the world, and its size had pushed contemporary technology and metallurgy to the limits. Consequently, no factory, nor contractor could produce the enormous crankshaft for the paddle engines; as well, no machinery existed powerful enough to hammer it into its final shape. Finally, Fulton and Neilson Company agreed to make an attempt, which was preformed at Lancefield Forge in Glasgow.[18] A series of special furnaces were built for this purpose as well as new steam hammers. The attempt failed twice but the third cast was a success.[19] Weighing over 40 tons, and costing some £4000 (£100 a tone),[20] the crankshaft was the largest successful forging preformed at that time, yet it was only a small step towards the completion of the monster ship.

Both the 7.2-meter-diameter screw and the 17.5-meter-diameter side-wheels[21] were used because of practical needs and not "overkill" in the design.[22] With such a layout, Brunel hoped to give the ship enough power to move her at a speed of 15-20 knots an hour. The typical single (sails) or double propulsion system (sails and side-wheels or a screw) was inadequate for moving the *Great Eastern* at that speed. Thus, the design of the separate engines and the propulsion systems was not for the purpose of better maneuvering in a harbour[23] or "engineering overkill,"[24] but rather, this design was the only way to move the great ship across the water. Although the screw engines could deliver 1600 horsepower and the side-wheels engines 1000 horsepower, Brunel's actual calculations called for a minimum of 4000 horsepower for the screw engines at 45 revolutions per minute and for 2600 horsepower from the paddle engines at 17 r.p.m., supplied by 15 lbs of steam pressure.[25] The steam engines that were built for the *Great Eastern*, however, had that power only in theory. The actual power on the screw shaft proved inadequate to move the gigantic ship across the ocean at the intended speed of 20 knots an hour.[26]

As late as 1858, the combination of two propulsion systems was still regarded as a strange concept, for the *London Illustrated* wrote: "The last application [of a screw shaft] is peculiar; it is that of applying the screw as a propelling power in conjunction with the paddle-wheel. This is being done in the last and most wonderful specimen of naval architecture, the Leviathan."[27] While the application of the screw and the side-wheels had clear practical purposes, the primary sources ignored the reason for employing the third propulsion system, the enormous sails of 5450 m^2, which were on six masts[28] and served as funnels for the auxiliary engines. This lack of any commentary on the use of sails might indicate that it was always assumed that the ship would have sails, despite its huge engines. In any case, the actual usefulness of these gigantic sails remains in doubt, since the placement of the ship's five smokestacks eliminated the use of the lower sails on masts two, three, four and five, thus greatly limiting the sail surface. One possible use for the sails could have been emergency use. However, Brunel's design originally equipped the *Great Eastern* with two smaller steamers attached to her sides high above the water line. In case of emergency, these could assist the ship and thus make the use of sails unnecessary. The ship was so enormous that power of sails would have been hardly adequate to move her, especially loaded with coal and cargo. Thus, this explanation for the use of sails is also highly problematic.

The most probable reason for the use of sails is that an 'ocean ship' was not considered as such, at that time, without sails, and, most likely, Brunel also had the same idea in mind when he envisioned the *Leviathan* around 1851. Some modern sources, completely ignore the fact that she had sails, and claim that the *Great Eastern* had only two propulsions, the screw and the side-wheels.[29] Such omissions, supported by the lack of pictures of the completed ship, might give the wrong impression that, in fact, she had no sails and thus was more 'modern' than she actually was. The *Great Eastern* was equipped with huge sails, and thus she had three, not two, independent propulsion systems. No ocean ship before or after her was ever equipped with three independent propulsion systems; in this respect, Brunel's ship was one of the most unusual vessels in history.[30]

The ship's hull was also revolutionary, not only for its double skin, watertight compartments, or its construction without the use of ribs, but for its 'modern' appearance [illustrations 4 and 5]. Brunel's earliest design of c.1851 strongly reflected the influence of the sail ships of that era and was in no way as 'modern'-looking as the final design of 1853. The final appearance of the *Great Eastern's* hull was based on the wave experiments preformed by Scott Russell.[31] The distinctive shape of the *Great Eastern*'s hull was afterwards reproduced in all gigantic ocean liners of the early twentieth century. Thus, the shape of the hulls of the *Lusitania*, *Olympic*, *Titanic* and the other famous ocean liners were parallel to the shape of the hull in Brunel's design. Although Brunel was given full credit for this departure from the old school of ocean-ship design, the positive role of Russell and his influence on the Brunel's work should also be acknowledged. No historian has given credit to Russell, who has been depicted as a villain in the *Great Eastern's* history, but Russell, and not Brunel, first experimented with the hydrodynamical models of ships[32] while he was working on his wave-line theory.[33] Hence, we should rethink the involvement of Russell in the project,

Illustration 4. The *Great Eastern* under construction, 1857.

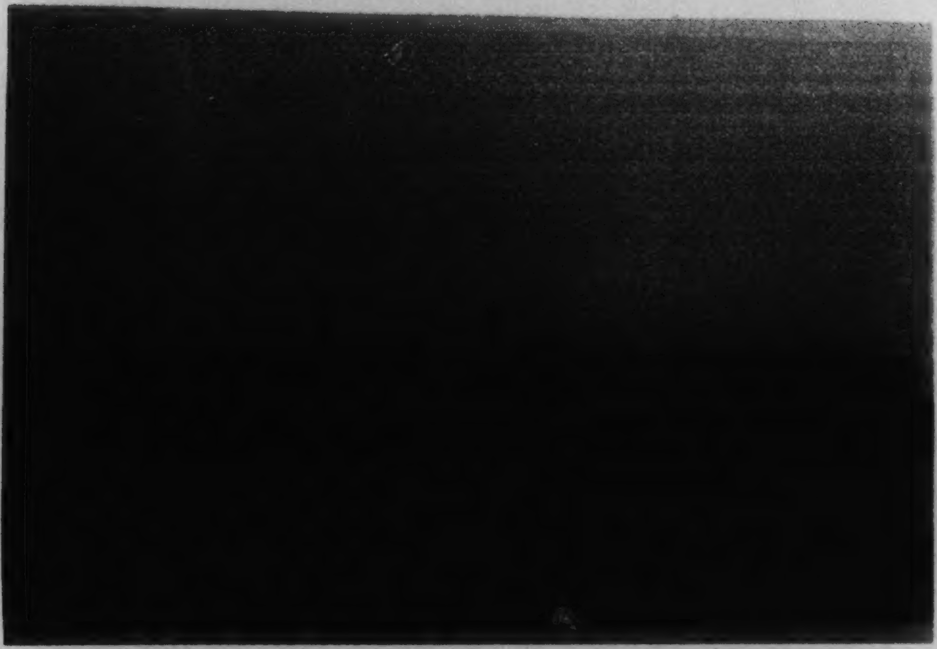


Illustration 5. The hull of the *Great Eastern* under construction, c. 1857.

and give him some credit for Brunel's hull design since it was shaped largely by Russell's earlier hydrodynamic experiments.

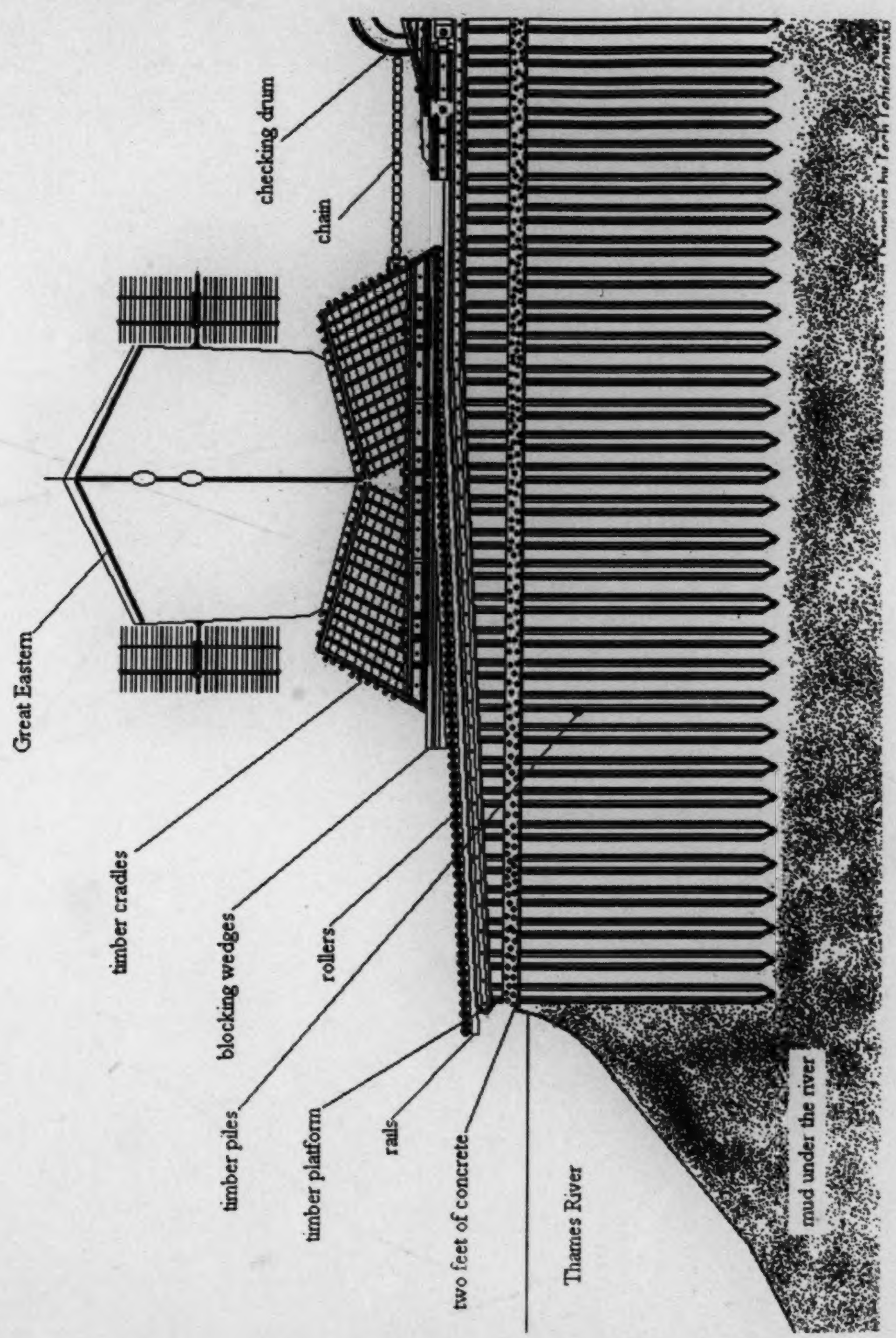
Although the design was excellent in its form, the actual moving of over 12,000 tons of iron from the Isle of Dogs some 100 meters into the water proved to be almost impossible. In September 1857, the hull was completed, Brunel now was faced with what some historians[34] describe as being the greatest engineering challenge of his career and that era, the launching of the great ship.

The launching of the *Great Eastern* was to set a new record and create new engineering problems for Brunel. Long before the attempted launch of the ship, Brunel experimented with scaled weighted cradles sliding on an inclined surface.[35] He carefully recorded the force required to push or slow down the weights. The purpose of these experiments was to determinate the best layout to make the launching of the *Great Eastern* as effortless as possible.[36] As a result of these experiments, Brunel designed and built two timber cradles that supported the ship, each over 40 meters wide, separated by an unsupported empty space under the ship's hull of 38 meters [illustrations 6 and 7].[37] Such a layout made the bow project some 60 meters beyond the cradles and the stern by over 50 meters, creating a total gravitational force of 1000 tons.[38] These giant cradles rested on 120 iron bars, which would act as rollers, being placed parallel on 160 railway rails [illustration 8].[39] The two launching slipways were 80 meters long and extended towards the Thames River. They were supported by 2 feet of concrete and some 2000 timber piles driven as deep as 10 meters into the mud, never to be recovered, as L.T.C. Rolt indicated: "Today [1957], when the Thames tides

Illustration 6. The Great Eastern under construction in 1857.

Illustration 7. The Great Eastern under construction in 1857.

Illustration 8. Transverse section through Brunel's slipways.


checking drum
chain
Great Eastern
timber cradles
blocking wedges
rollers
timber piles
timber platform
rails
two feet of concrete
Thames River
mud under the river

recede, the timbers of the ways which once launched the Great Eastern still appear in the mud below the Napier Yard at Millwall."[40] The bars (rollers) had 9000 points of contact with the rails, thus providing about 1.33 tons of load force on each point of contact. [41] The gravitational force, combined with the use of simplified rollers, was not enough to move the *Great Eastern* into the water. Brunel in his original design envisioned the use of hydraulic launching gear to assist the ship during her floating, providing enough pulling and stopping force. As was discussed in Chapter Two, Russell and the directors of the Eastern Steam Navigation Company rejected this original design. Without the hydraulic launching gear, Brunel had to devise a new plan for moving and slowing down the ship on the slipways.

The two major engineering problems that Brunel had to solve before attempting to launch the vessel involved how to make her move and how to slow her down so that her enormous weight would not cause her to slide out of control, causing extensive damage to her hull. To solve the problem of the uncontrolled slide, Brunel designed two gigantic checking drums at the head of each launching way. These were 6.10 meters long and 2.74 meters in diameter[42] and weighed some 60 tons each [illustrations 9 and 10].[43] These were used to house a chain[44] which was connected to the ship. Applying manual brakes to these drums would, in theory, slow her descent into the river. Due to a lack of time, and pressure from the directors, Brunel had no time to test the chains or the tackles.[45] In any case, he had no choice, for no stronger chain was available in the world, at that time. He borrowed the chains he used during the attempted launching of the *Great Eastern* from the British Admiralty.[46]

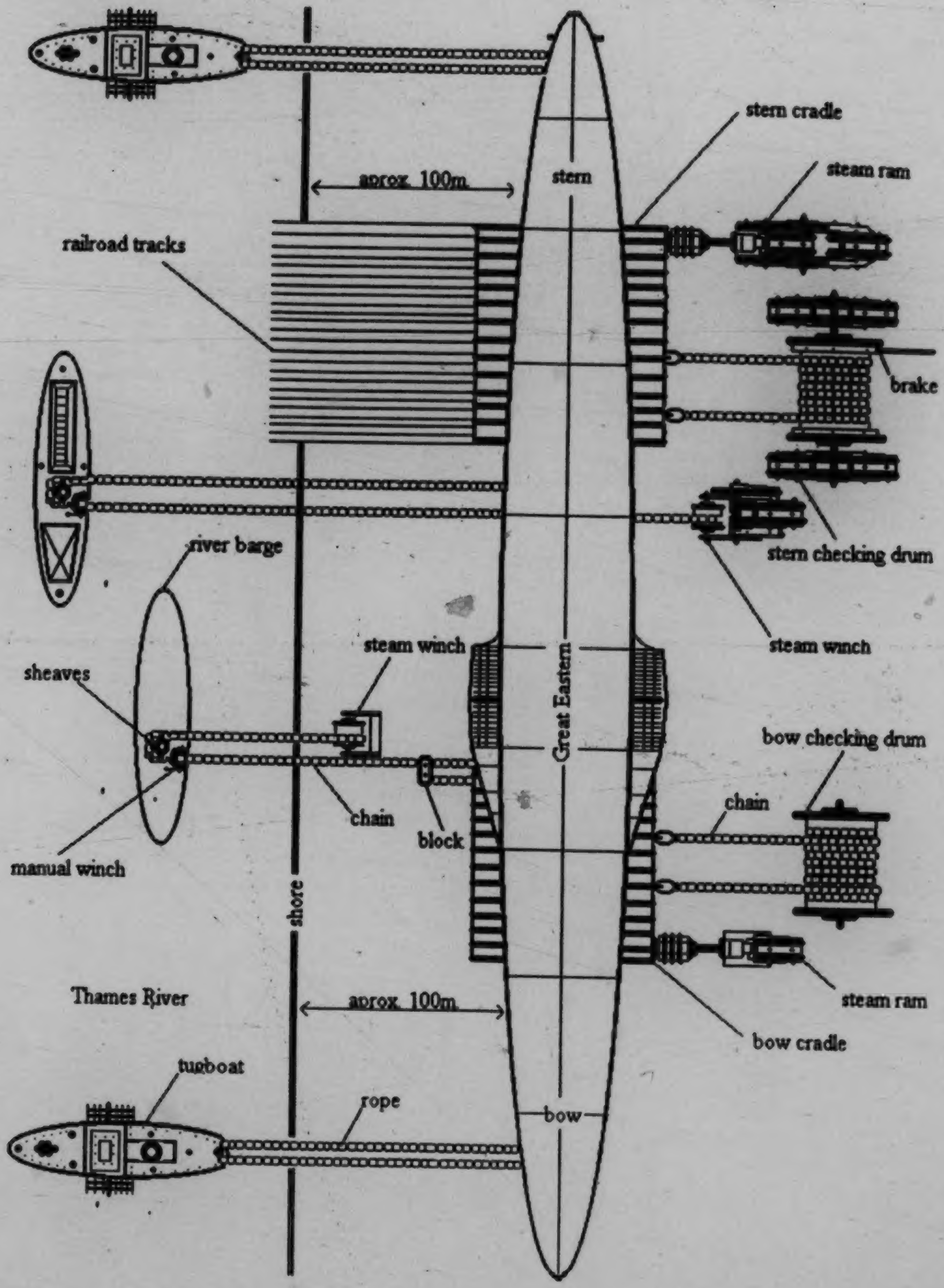
Illustration 9. On of the gigantic checking drums 1857.

Illustration 10. The rear checking drums 1857

To solve the problem of moving the ship into the water, Brunel proposed an elaborate design that combined the pulling and the pushing force from the land and the water [illustration 11]. The enormous tackles (the size of a man) were attached to the stern and the midsection of the ship, and the chains that passed through them were passed through sheaves on barges that had been placed on the river for this purpose, and then were directed back to the shore where they were finally attached to the steam winches. To provide an additional pulling power, four 80-ton manual winches were also placed on the moored barges.[47] Brunel also had two steam rams placed at the vessel's bow and the stern, so that if his chains and tackles failed, he could still attempt to initiate the ship's movement down the launch ways. These proved to be more efficient than Brunel had planned and later on caused the uncontrolled slide of the stern. The total power of all the pulling and pushing gear was estimated at about 1100 tons, with the force of gravity creating the total moving force of 2100 tons.[48] With these arrangements made, Brunel announced that the long expected event would take place on November 3, 1857. Once the announcement was made, the launch was out of Brunel's control.

The launching of the *Great Eastern* was such a famous and long-expected event that the public demanded participation in this history-making process. This demand proved to have fatal consequences for all. Brunel had foreseen problems, so in order to calm the public down, he published a press statement explaining that the launching of the ship would be a boring and tedious process, and that, in fact, it would not be a 'launch' but only a lowering of the ship close enough to the water that she could float on the Thames tide. He explained, "The launch is likely to be a long and tedious affair,

Illustration 11. The launching of the Great Eastern, top view.


stern cradle
aprox. 100m.
stern
steam ram
railroad tracks
brake
stern checking drum
river barge
steam winch
steam winch
sheaves
Great Eastern
bow checking drum
chain
chain
block
manual winch
shore
steam ram
Thames River
aprox. 100m.
bow cradle
tugboat
rope
bow

which will probably occupy eight to ten hours."[49] He also explained that two factors would determine the success of the launch, the successful operation of the machinery and complete silence during the launch:

> Provided the mechanical arrangements should prove efficient, the success of the operation will depend entirely upon the perfect regularity and absence of all haste or confusion in each stage of the proceeding and in every department, and to attain this nothing is more essential than perfect silence. I would earnestly request, therefore, that the most positive orders be given to the men not to speak a word and that every endeavour should be made to prevent a sound being heard, except the simple orders quietly and deliberately given by those few who will direct.[50]

Moreover, he also demanded, in a letter to Yates (the company's secretary), "I must have sole possession of the whole of the premises on the day of the launch, no men, even of our own still less strangers, in any part of the yard except those regularly told off for their respective duties."[51] What followed was the exact opposite of what Brunel asked or hoped for. The directors turned the launch into a spectacle, and Brunel was forced to play a major role in it.[52] A *Times* reporter explained that the public's high expectations and the long anxiety while waiting for this 'spectacle' made people willing to be at the event at any cost:

> Men and women of all classes were joined together in one amicable pilgrimage to the East, for on that day, at some hour unknown, the Leviathan was to be launched at Millwall.... For two years, London – and we might add, the people of England – had been kept in expectation of the advent of this gigantic experiment, and their excitement and determination to be present at any cost....[53]

This determination drove "the people of England" by the thousands to Napier's Yard, along with countless visitors invited by the directors, entire families and friends of the two thousand workers,[54] and those who wanted to witness the event from the water. Yates sold over 3000[55] admission tickets to the yard. Moreover, at night before the launch, grandstands were being built nearby for the thousands who would not manage to enter the shipyard.[56] The directors had decided to make a great profit from the event and issued thousands of tickets for the *Great Eastern*'s launch after Brunel had announced the date of its attempt.

Although James Dugan claimed that "[Brunel] did not know that company directors had issued the tickets"[57] and L.T.C. Rolt made the same argument in his book,[58]this claim is not credible. Brunel's letters, quoted above, indicate that he was aware of the problem and tried to minimize any involvement of people unassociated with the actual launching process of the ship. Also, if thousands of tickets were sold, it is hard to imagine that Brunel did not know about them. Surely, he did not expect the public to overwhelm the yard, but he must have had a good idea of what was going on. Nevertheless, the reality must have far exceeded his worst nightmares.

On October 24, 1857, the lowering of the ship into its cradles began, by knocking out the wooden supports with the use of hydraulic lifts [illustrations 12 and 13].[59] Meanwhile, the selling of the tickets proceeded, and the entire gallery at the stern of the *Great Eastern* became the "exclusive property of Scott Russell."[60] Russell, compared to the tired and dirty Brunel, looked like the finest gentleman in England, as Woods noted: "the elegant appearance [of Scott Russell] and general urbanity were in marked contrast to the style and manners of many other important gentlemen present…."[61] Brunel, unable to leave the yard since October 24, was present at the site day and night, working restlessly to get the ship ready for the intended September launch. Consequently, on the day of the great event, N.A Woods, a *Times* reporter, described him as looking like "a respectable carpenter's foreman."[62] As a result of his

Illustration 12. The Great Eastern being built, 1857.

Illustration 13. The Great Eastern being built, 1857.

restless and hard work, on September 3, 1857, as Brunel expected, the ship was ready for its launch [illustration 14].

The first attempt at launching the *Great Eastern* took place on September 3, at about 12:30 pm [illustration 15].[63] Woods claimed that over 10,000 people were present at the yard at dawn, while, by noon, there were over 100,000 spectators.[64] He probably could not have actually counted such a number, but Brunel was overwhelmed, overworked, and angry with the directors, who had completely disregarded his decisions and suggestions.[65] Brunel, however, proceeded with the launching and supervised the final greasing of the rollers and the rails on the slipways. Then after he had ordered the blocking wedges from the two cradles to be removed, the earth began to shake under the horrified crowd. For over ten minutes, the ship made a tremendous noise, being pulled by the manual winches on the barges and the steam winches on shore, but she would not move.[66] Brunel then ordered the use of the two hydraulic rams, and "their effect was so dramatic that in the general excitement and turmoil, no one could agree afterwards as to the exact sequence of events."[67] The movement of the gigantic structure appears to have caused an outburst of both panic and excitement that was beyond any control. As a result, Brunel was unable to hear or to be heard, the stern section of the *Great Eastern* moved with a horrible screech and at a terrifying speed. However, the crew of the stern-checking drum did not apply the brake, probably because the crew's members were overwhelmed by the crowd and the event.[68] Consequently, as the ship moved rapidly down, the slack of the chain was taken by the hull's movement, and the 60-ton drum begun spinning in reverse. Its force caused the winch handles to act as a catapult, sending two[69] workers high into the air

Illustration 14. The launching of the *Great Eastern*, October 1857.

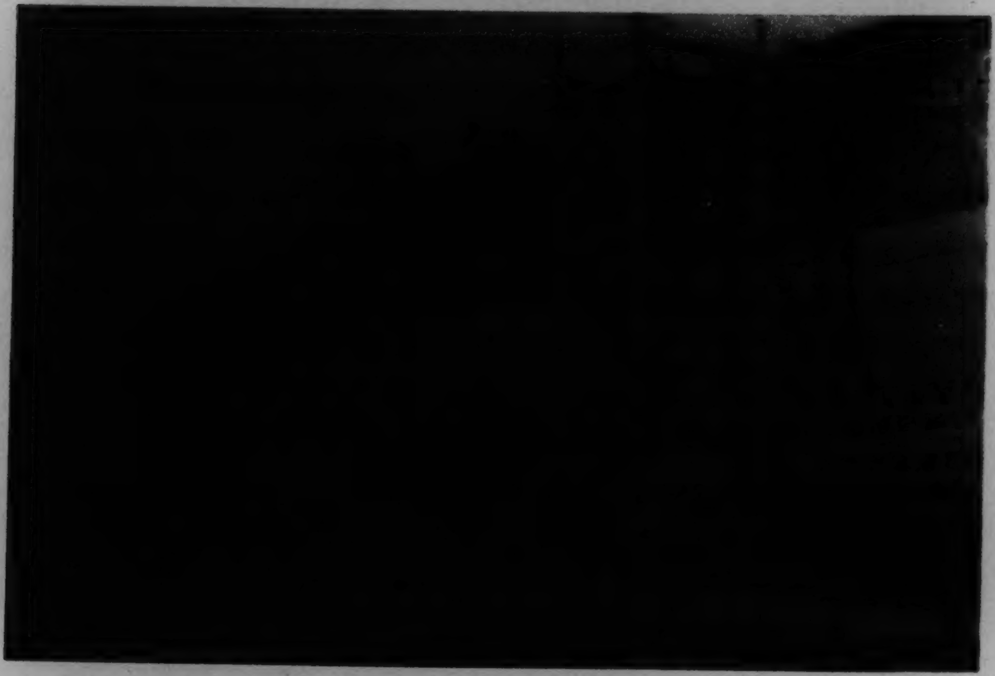


Illustration 15. The launching of the *Great Eastern*, October 1857.

above the terrified crowd, two were killed and three were seriously injured.[70] The accident caused uncontrollable panic and turmoil. As well, the rapid movement of the ship and the situation on the shore caused great confusion on the moored barges, as the gigantic hull was moving with great speed and noise towards the barge crews. These were commanded by Captain Harrison, who was unable to stop his men from jumping into the river and swimming away from the site.[71] In the face of all these misfortunes and the general panic, Brunel decided to stop the launch. The crew of the forward drum, commanded by foreman Ned Hepworth,[72] applied its brake, and the ship stopped. Perhaps, if Brunel had not stopped the launch the ship, could, in fact, have been launched, but once she lost her initial momentum, the vessel seized up on the slipways and did not move.[73]

The second attempt, which followed on the same day at 2 pm, did not result in any movement of the ship. In a heavy rain, the chains snapped, the ship made noise, one of the river barges was dragged by the force of the steam winches, but the *Great Eastern* would not move.[74] Afterwards as Brunel's son, Henry Brunel, indicated, "The whole yard was thrown into confusion by a struggling mob, and there was nothing to be done but to see that the ship was properly secured, and to wait till the following morning."[75] As a consequence of the two failed attempts, Brunel wrote to Samuel Baker, one of the directors:

> I learnt to my horror that all the world was invited to The Launch and that I was committed to it coute que coute. It was not right, it was cruel; and nothing but a sense of the necessity of calming all feelings that could disturb my mind enabled me to bear it....[76]

To the general public, however, Brunel was to blame for all that had happened during the launch, and during this period, the *Great Eastern* began to be regarded as an engineering fiasco. Many claimed that she could never be moved into the water and would rust on shore, and Brunel was heavily criticized. One article from *The Field* said:

> Why do great companies [such as that of Scott Russell] believe in Mr. Brunel? It is because he really is a great engineer? If great engineering consists in effecting huge monuments of folly at an enormous cost to shareholders, then Mr. Brunel is surely the greatest of engineers.... Mr. Brunel could ... have made a better line [the Western Railway] by going round the hill. But no: another monument to his vanity was needed, and so through it he went....[77]

Brunel was aware of the papers' attacks, but, as far as we know, he kept his thoughts on this subject to himself and did not reply publicly to the allegations. These days were surely bad for him and the ship. His personal correspondence indicates that during this period, Robert Stephenson provided him with the moral strength to go on. In order to help his friend, Stephenson emerged from retirement,[78] and until the end, gave Brunel the confidence and support he needed to finish the ship. Stephenson wrote: "Never mind Russell or the papers. I shall always be at hand happen what may, to aid and do everything in my power without shirking any responsibility if need be."[79] Overall, Stephenson's friendship had an important positive impact on the further progress of the ship.

Meanwhile, encouraged by his friend Stephenson, Brunel added more pushing power by acquiring two more hydraulic presses of 800 tons, resulting in a total moving force of 2900 tons. On November 19, another attempt to launch the ship was made, but this time, only on the bow section, for the stern was already too far ahead. The stress on the chains was overwhelming and they snapped, so the ship did not move. Afterwards, Brunel recovered the precious chains from the riverbed and made some improvement to the steam presses. He also borrowed more chain from the Brown and Lenox Company.[80] On Saturday, November 28th, another attempt to move the bow was made.

It moved 2.5 centimeters at first, and once set in motion continued to slide at a rate of about 2.5 cm a minute. After the ship had moved 30 cm, Brunel ordered his crew to use the stern presses to push, and the river winches to pull. These failed, causing the loss of the chain, and the dragging of the river barges. After each failure Captain Harrison and his men had to recover the lost chains and reestablish their connections. Moreover, the tackles were unable to handle such stress and failed as well. However, the presses worked and by sunset, the ship had moved a total of 4.27 meters.[81]

Since the tackles and pulling could not be relied upon, Brunel devised a new plan for pushing the ship into the water. The process was based entirely on the use of hydraulic presses, which had proved so successful during the first launch. However, the use of these devices greatly extended the time needed for the launching of the ship. Every time that the rams of the presses were extended to their limits as the ship moved, they had to be moved and reset accordingly. On Monday, November 30, the *Great Eastern* was moved a total of 10.1 meters towards the water. During the next day the further progress of 43 cm was made, and Brunel was hoping to float the ship by taking advantage of the tide on December 2. However, the presses at the forward section exploded, and before they were repaired on December 3, the tide had passed.[82] On the same day, the ship was moved 4.27 meters and on December 4 another 9.14 meters, but at this point, two more presses exploded, and the launch was terminated. The *Times* wrote:

> It was something unheard of in the history of mechanics. In fact the accident to a windlass, when a side of its massive iron drum round which the chain was coiled, was crushed like a nut, was not only never known to occur before, but until yesterday such a breakage was considered almost impossible. Through the sides of a hydraulic ram ten inches in diameter, the water was forced through the press of the solid iron like a thick dew, until the whole cylinder ripped open

> from top to bottom with a noise like a dull underground explosion. The iron of this cylinder averaged six inches [15.3cm] thickness and stood a pressure upwards of twelve thousand pounds per square inch before it gave away. The massive cast iron slab against which the base of another ram rested was split like a board, but this of course, was mere bagatelle among the other mishaps....[83]

At that point, Robert Stephenson convinced Brunel to wait for more powerful presses, as the ship needed more power in order to be moved.[84] Meanwhile, letters offering help were sent from around the world to Brunel, and the *Times* also supported the cause by printing some of them. Most ideas were completely impractical, but Brunel collected all of them in a separate folder for future consideration and this file still survives today.[85] The most 'entertaining' of these were the suggestions to blow up part of the yard to make the ship move, to build a channel, order thousands of troops to march on one side of the ship's deck, and to shoot cannons at the cradles. Three of Brunel's correspondents advised him,

> ...I would put one or two thousand men on board the ship and give them a signal by trumpet alarm to unite in jumping and I should not fear but the vibration created would be effectual, together of course with your other appliances, to set the machine in motion.... It strikes me that if several large guns were loaded with powder only and placed alongside of Leviathan and fired simultaneously with the hydraulic rams and other machinery in operation that the explosion would give an impulse to the Ship and cause her to move off easily.... Could not 50 Navigators (with materials ready) stop the tide above Chelsea, and then raise the Thames for you?[86]

Some of these individuals actually believed in their engineering 'genius' and insisted upon being allowed to enter the shipyard and perform their wild propositions. Brunel's careful study of even the most improbable proposals shows how desperate he was,[87] and what an enormous engineering challenge the launch of the *Great Eastern* turned out to be. While patiently waiting for the more powerful presses, Brunel replied to most of these letters. By Tuesday January 5th 1858, Brunel had managed to gather 21 presses,[88] increasing the total pushing power from 1100 to 4000 tons,[89] with 1000 tons of gravity force and some 1000 tons of pulling power provided by the tugboats, which were, however, not used in this attempt, so that the total moving force was about 6000 tons. This, we should remember, constituted half of the ship's hull weight.[90]

Sir Richard Tangye produced the new presses.[91] As a result of launching of the great ship, Tangye became so successful that he started his own company and prospered enormously from the Brunel's misfortunes. He boasted: "We launched the *Great Eastern* and the *Great Eastern* launched us."[92]

The Eastern Steam Navigation Company by now was in trouble. It had to pay for the lost chains, the broken presses, and the launch. The costs to the company were estimated to be some £1000 a foot (30.5 cm).[93] Meanwhile, Brunel was working restlessly to get the ship into the water, living at the yard, working in rain, mud and bitter cold, neglecting his family and his health. By January 1858, he was exhausted.[94]

On January 5th, another attempt was made, an event that modern historians have reported in two contradictory ways. Dugan claimed that the ship had moved some 7.5 cm before the rams burst into pieces, and that everything that happened on that day was thus a complete disaster.[95] L.T.C. Rolt claimed that the launch was in fact a success, and that the only problem that Brunel experienced was the bad weather.[96] To clarify this large discrepancy in the secondary sources, we have to turn directly to a primary source, from Wednesday, January 6th 1858, which informs us that:

> Yesterday morning the slow pushing efforts which constitute the process of launching this vessel were recommenced for the sixth time.... By the new arrangement, by which all the hydraulic machines are joined with supply pipes in groups of three, the pressure was got upon the cradles so equally that the Leviathan, after a rest of nearly three weeks, slipped at once for two or three inches, and in short slips of the same kind she continued to progress throughout

> the day… Her whole progress was 8 feet 3.5 inches [2.53 meters] aft and 3 feet 1 inch [94cm] forward.[97]

Thus, the *Times* indicates that both Dugan and Rolt, and the other historians who relied on Rolt's and Dugan's descriptions, were incorrect. While the launch was not a success, it was not a failure or a disaster. Nothing indicated that the presses had burst into pieces or that any misfortunes had occurred except for a relatively minor problem: "the day before… the steam barge, with the gear for hauling in the chains was sunk by a bark, [consequently] nothing could be done with the river tackle."[98] The progress made that day was about 2.53 meters for the stern and 94 cm for the bow. As the *Times* reported, the slow progress continued each day,[99] until on January 28th, Brunel stopped the launching process, for the ship was so close to the water that he was afraid she might float off uncontrolled with the rising tide.[100] To prevent her from doing so, he ordered fireboats to pump some 27,000 litters of water into the hull in order to increase her weight and thus prevent her from floating away. Brunel set January 30th as the day for the final attempt, as the *London Illustrated* indicated: "Success has at length crowded the efforts of Mr. Brunel, the Leviathan having been placed on Thursday in so satisfactory a position that her lunch at the next spring tide (on the 29th or 30th) will not be a matter of the slightest difficulty."[101] He also, fearing that the hull might be damaged, removed the riverside cradles and replaced them with smaller wooden wedges. Moreover, four tugboats — the *Victoria*, *Friend To All Nations*, *Napoleon* and the *Perseverance* — were called to the site in order to tow the ship to a safe berth at Deptford.[102]

On the night of January 30, 1858, everything was ready. However, the violent weather made the launch impossible, so the attempt was terminated, as the tugs would not have had enough power to tow the *Great Eastern* into safety. Brunel had only one more chance before the next spring tide: on the next day, January 31. The weather improved, and around 3.30 am, the pumping out of the water begun. By 6 am, the 2700 tons of water had been removed,[103] and the ship was ready for floating. At 10 am, the presses were used for the last time, giving her the necessary push, at 1:20 pm, the stern was floated and finally at 1:42 pm, [104] the entire ship was on the Thames River, as the *London Illustrated* indicated: "The completion of the launch of this stupendous and beautiful vessel took place on Sunday last, under the most favorable circumstances, unattended with a single accident; and the Leviathan now rides softly at her moorings off Deptford."[105] The operation ended as another unprecedented engineering success for Brunel. However, he was exhausted and the Eastern Steam Navigation Company was in a state of financial ruin. Consequently, he and the company had only two alternatives: sell the ship at an open auction, or form a new company that would finish her.

The second option was adopted, and on November 18, 1858, the Great Ship Company was established with Campbell as chairman, Yates as secretary and Brunel as the engineer.[106] On the 25th of November, the company purchased the hull for £165,000, and on December 17th, the Eastern Steam Navigation Company ceased to exist. It was the first owner to be bankrupted by the expenses associates with the great ship.[107] The *Great Eastern*, in fact, was still nothing more than an empty, unfitted, gigantic iron hull. The new company thus had to find a way to reduce the outfitting costs. Consequently, the two smaller steamers that were to be suspended on the sides of the ship were abandoned, and the accommodations for the intended 4000 passengers were not finished.[108]

During this time, Brunel's health declined rapidly, and he was forced to move to a warmer country, Egypt, before the outfitting contracts for the ship were signed. While he was in Egypt, Brunel learned that Wigram and Lucas Company, which he had recommended should receive the outfitting contracts, estimated to worth £142, 000, had been rejected, and that Scott Russell had been granted them.[109] This information must have hurt Brunel deeply, especially since Russell, as before, had presented unrealistically low estimates for the outfitting. The company's directors had decided to ignore Brunel's recommendation.[110] Their reasons for making this decision are unknown, but one fact stands out: the *Great Eastern's* gigantic steam engines were still unfinished and untested. Although Russell was removed from the work on the ship's hull, his contracts for finishing her engines and performing their trials were still valid. Thus, the directors, and consequently, Brunel, might have been forced to accept Russell's proposal, or else to finish and test the engines themselves.

As before, Russell neither fulfilled his contracts, nor accepted Brunel's ideas. Consequently, Brunel was forced to take over the whole operation once more and supervise everything himself. This decision proved deadly, but because of his direct involvement, the ship's construction rapidly proceeded. As the *London Illustrated* noted,

> The rapidity with which her internal fittings have been completed is not the least remarkable fact in the ship's most remarkable history. Two or three months ago she was nothing but a huge shell, blank and unmeaning without, and within a scene of chaos and confusion from stem to stern. On Monday she floated upon the water trim as a cutter, her five masts up and fully rigged, her noble deck smooth as a bowling green, her tremendous engines in complete working order, and her spacious saloons invitingly ready for the very numerous company who partook of the hospitality of the directors....[111]

However, the constant and countless struggles with Russell, and the physical and emotional stress, had changed Brunel greatly. All his biographers and his photographs indicate that he was working himself to death [illustrations 16, 17 and 18]. His brother-in-law, John Horsley, wrote these words to him:

> I would implore you to reflect upon that hour of death which must come upon you sooner or later, and whether, at that awful moment, you will be able to look with satisfaction upon your life, which has been one of almost unparalleled devotion to your profession, to the exclusion, to far too great an extent, of that which was due to your God and even to your family, and with an utter disregard of your health….
> My dear friend, will all this bring you peace at the last?[112]

In August 1859, the outfitting was finished, and the grand vision created by Brunel's intellect and immense work was completed. The *London Illustrated* observed:

> The close of the London season of 1859 will be marked in the chronicles of our time by one of the greatest facts of our age. On Monday the Great Eastern steamship may be said to have received her confirmation as a vessel ready for sea, and that grand service for which she is destined. The time has at length arrived when a few days will solve the all-important problem of whether a ship of 23.000 tons burden, and capable of carrying a population of 10,000, could be made to travel the ocean at the rate twenty miles an hour, and to bring Calcutta within thirty days sail of London, thus supersede all the present complicated arrangements… If seven was hitherto the orthodox number of the wonders of the world, the Great Eastern may now fairly rank as the eighth; and further, and without any contradiction, may take place before her predecessors, as being beyond all comparison the greatest wonder of them all.[113]

With the successful completion of the ship, Brunel had only one wish left: to "accompany her when she put out upon her maiden voyage."[114] The day before she was to start her ocean trials on September 5th, Brunel came on board to make the final inspection of his creation and to insure that she was ready for the voyage. To commemorate his final victory and completion of the ship, Nottage of London Stereoscope Company took a picture of him [illustration 18]. Moment after the picture was taken,[115] he suffered a stroke on the deck of his grand ship and never recovered.[116]

Illustration 16. Brunel photographed in c. 1858, in the background the checking drum's brake.

Illustration 17. Brunel photographed in 1858, in the background the checking drum's chains.

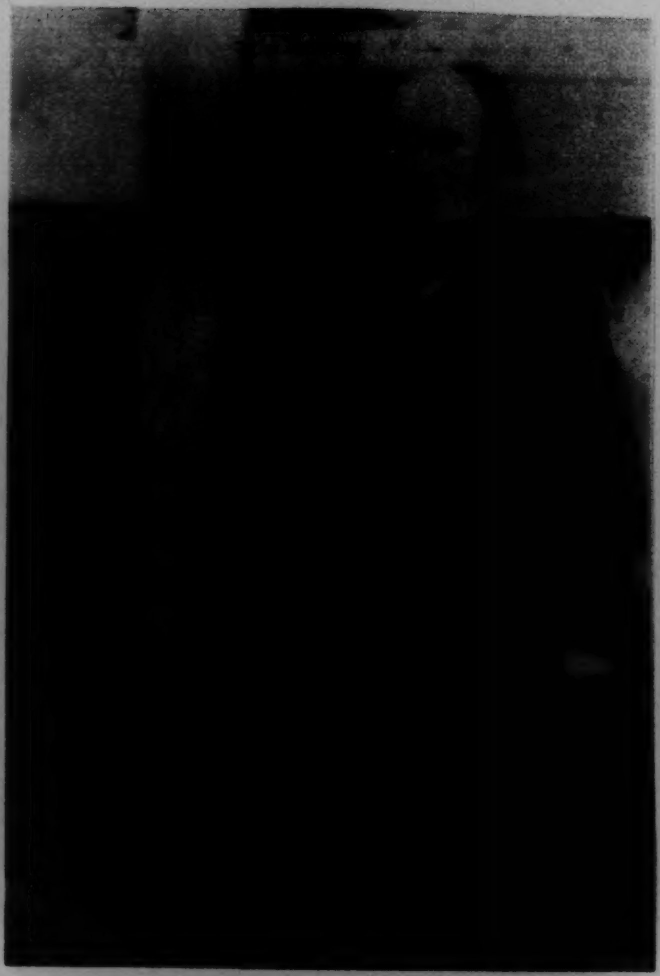


Illustration 18. The last picture of Brunel, moments after the picture was taken he suffered a stroke

Brunel, paralyzed and dying, waited for the news of the successful engine trials. His last words before the stroke expressed his concern about accepting the engines from Russell, without proper testing. He advised McLellan, chief of paddle engines, not to accept them from Russell before they had been tested at sea,[117] as he suspected that the engines were not yet ready for use. Shortly, his fears proved to be correct, and when news of an immense explosion on board the *Great Eastern* reached him, he expired.

This chapter explored in detail the specifications and construction of the ship from 1857-1859 and discussed her long launching process, demonstrating what an enormous engineering challenge the launch of the *Great Eastern* turned out to be. This chapter also demonstrated that Brunel and not Russell built the ship, although the primary and some secondary sources have given Russell full credit for the construction. The chapter also argued that many of the *Great Eastern*'s problems might have been avoided if it was not for the company's management, which repeatedly, for reasons unknown, reemployed Scott Russell. This policy caused more expenses, created more delays, and contributed to Brunel's collapse.

Notes

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[1] James Dugan, The Great Iron Ship, p. 9.

[2] Henry Fry, The History of North Atlantic Steam Navigation (New York: Charles Scribeners's Sons, 1896), p. 182.

[3] John Guthrie, Bizarre Ships of The Nineteenth Century (South Brunswick: A. S. Barnes, 1970), p. 127.

[4] Ten transverse and two longitudinal.

[5] James Dugan, The Great Iron Ship, p. 5.

[6] James Dugan, The Great Iron Ship, p. 267.

[7] James Dugan, The Great Iron Ship, p. 267.

[8] The legend about the workers who were sealed alive in the double hull seems to have been born shortly after the construction of the ship in 1857. From the start, this legend gave her a bad reputation amongst the sailors, which was further strengthen by her countless mishaps during her life.

[9] James Dugan, The Great Iron Ship, p. 5.

[10] James Dugan, The Great Iron Ship, p. 5.

[11] During the construction of the Western Railway, for example, over 100 men and children died. John Pundney, Brunel and His World, p. 50.

[12] L.T.C. Rolt, Isambard Kingdom Brunel, p. 248.

[13] Scientific American-Supplement, "The Great Eastern", No 672, vol. 26,November 17, 1888, p. 10734.

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[14] Scientific American-Supplement, "The Great Eastern", No 672, vol. 26,November 17, 1888, p. 10734.

[15] Scientific American-Supplement, "The Great Eastern", No 672, vol. 26,November 17, 1888, p. 10734.

[16] L.T.C. Rolt, Isambard Kingdom Brunel, p. 248.

[17] L.T.C. Rolt, Isambard Kingdom Brunel, p. 248.

[18] L.T.C. Rolt, Isambard Kingdom Brunel, p. 249.

[19] L.T.C. Rolt, Isambard Kingdom Brunel, p. 249.

[20] L.T.C. Rolt, Isambard Kingdom Brunel, p. 249.

[21] Jerzy Micinski, Archiwum Neptuna (Warszawa: Wdawnictwo Ministerstwa Obrony Narodowej, 1957), p 172.

[22] Sally Dugan, Men of Iron, p. 156.

[23] Sally Dugan, Men of Iron, p. 156.

[24] Sally Dugan, Men of Iron, p. 155.

[25] L.T.C. Rolt, Isambard Kingdom Brunel, p. 241.

[26] The fastest recorded speed of the *Great Eastern* was 15 knots.

[27] London Illustrated, "The Leviathan" No. 898, Vol. XXII, Saturday, January 16, 1858, p. 70.

[28] Jerzy Micinski, Archiwum Neptuna, p. 173.

[29] Such as: Sally Dugan, Men of Iron or Peter Kemp, Encyclopedia of Ships and Seafaring.

[30] Jerzy Micinski, Archiwum Neptuna, p. 172.

[31] Peter Kemp, Encyclopedia of Ships and Seafaring, p. 86.

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[32] Peter Kemp, Encyclopedia of Ships and Seafaring, p. 86.

[33] The wave line theory was proposed by Scott Russell in 1854. See "Report on Waves": Report of the fourteenth meeting of the British Association for the Advancement of Science, York, September 1844 (London 1845), pp 311-390. In reality, this theory had little to do with the ship's design, Russell was interested in a phenomena he called the 'wave of translation,' and he used different ship models to observe this process. Because of these experiments, the more hydrodynamic and 'modern' shape of ship's hull was later developed. The most important of these was the distinctive straight bow design of the *Great Eastern*, later used on all ocean liners, up to 1935.

[34] L.T.C. Rolt, Isambard Kingdom Brunel, p. 266.

[35] L.T.C. Rolt, Isambard Kingdom Brunel, p. 266.

[36] L.T.C. Rolt, Isambard Kingdom Brunel, p. 267.

[37] L.T.C. Rolt, Isambard Kingdom Brunel, p. 267.

[38] L.T.C. Rolt, Isambard Kingdom Brunel, p. 267.

[39] James Dugan, The Great Iron Ship, p. 9.

[40] L.T.C. Rolt, Isambard Kingdom Brunel, p. 313.

[41] L.T.C. Rolt, Isambard Kingdom Brunel, p. 267.

[42] L.T.C. Rolt, Isambard Kingdom Brunel, p. 267.

[43] James Dugan, The Great Iron Ship, p. 12.

[44] James Dugan, The Great Iron Ship, p. 13.

[45] L.T.C. Rolt, Isambard Kingdom Brunel, p. 267.

[46] James Dugan, The Great Iron Ship, p. 9.

[47] L.T.C. Rolt, Isambard Kingdom Brunel, p. 267.

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[48] L.T.C. Rolt, Isambard Kingdom Brunel, p. 267.

[49] Brunel incorrectly was quoted by James Dugan as the Time's reporter, in The Great Iron Ship, p. 9.

[50] Brunel quoted by John Pundney in Brunel and His World, p. 99.

[51] Brunel quoted by L.T.C. Rolt in Isambard Kingdom Brunel, p. 268.

[52] John Pundney, Brunel and His World , p. 98.

[53] Quoted by John Pundney, in Brunel and His World, p. 98.

[54] James Dugan, The Great Iron Ship, p. 10.

[55] L.T.C. Rolt, Isambard Kingdom Brunel, p. 269.

[56] James Dugan, The Great Iron Ship, p. 10.

[57] James Dugan, The Great Iron Ship, p. 10.

[58] L.T.C. Rolt, Isambard Kingdom Brunel, p. 269.

[59] L.T.C. Rolt, Isambard Kingdom Brunel, p. 270.

[60] N.A. Woods of the Times, quoted by L.T.C. Rolt in Isambard Kingdom Brunel, p. 270.

[61] Woods quoted by L.T.C. Rolt in Isambard Kingdom Brunel, p. 270.

[62] N.A. Woods of the Times, quoted by James Dugan in The Great Iron Ship, p. 11.

[63] L.T.C. Rolt, Isambard Kingdom Brunel, p. 271.

[64] James Dugan, The Great Iron Ship, p. 11.

[65] L.T.C. Rolt, Isambard Kingdom Brunel, p. 270.

[66] L.T.C. Rolt, Isambard Kingdom Brunel, p. 271.

[67] L.T.C. Rolt, Isambard Kingdom Brunel, p. 271.

[68] John Pundney, Brunel and His World, p. 98.

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[69] The number of workers who were catapulted was estimated by Dugan as a dozen. This figure, was however, highly exaggerated. In fact, only one man, named Donovan, who was not part of the drum's crew, was 'catapulted' and died as a result of serious injuries. Rolt presents a more accurate description of this event; see L.T.C. Rolt in Isambard Kingdom Brunel, p. 271.

[70] L.T.C. Rolt, Isambard Kingdom Brunel, p. 272.

[71] L.T.C. Rolt, Isambard Kingdom Brunel, p. 271.

[72] L.T.C. Rolt, Isambard Kingdom Brunel, p. 272.

[73] Argument made by John Pundney, Brunel and His World, p. 99.

[74] L.T.C. Rolt, Isambard Kingdom Brunel, pp. 272 - 273.

[75] Henry Brunel quoted by L.T.C. Rolt in Isambard Kingdom Brunel, p. 272.

[76] Brunel quoted by L.T.C. Rolt in Isambard Kingdom Brunel, p. 270.

[77] John Pundney, Brunel and His World, p. 99.

[78] John Pundney, Brunel and His World, p. 100.

[79] Robert Stephenson quoted by John Pundney in Brunel and His World, p. 101.

[80] James Dugan, The Great Iron Ship, p. 15.

[81] L.T.C. Rolt, Isambard Kingdom Brunel, p. 275.

[82] L.T.C. Rolt, Isambard Kingdom Brunel, p. 276.

[83] The Times quoted by James Dugan in The Great Iron Ship, p. 16.

[84] L.T.C. Rolt, Isambard Kingdom Brunel, p. 276.

[85] John Pundney, Brunel and His World, p. 100.

[86] Brunel's correspondence quoted by John Pundney in Brunel and His World, pp. 99 - 100.

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[87] John Pundney, Brunel and His World, p. 100.

[88] The Times, "The Leviathan", Issue 22883, Wednesday, Jan 6, 1858, p.11.

[89] L.T.C. Rolt, Isambard Kingdom Brunel, p. 279. incorrectly gives the figure as 4500 tons and the amount of rams as 18. For the correct numbers, see The Times, "The Leviathan", Issue 22883, Wednesday, Jan 6, 1858, p.11.

[90] James Dugan, The Great Iron Ship, p. 15.

[91] James Dugan, The Great Iron Ship, p. 17.

[92] James Dugan, The Great Iron Ship, p. 17.

[93] John Pundney, Brunel and His World, p. 99.

[94] L.T.C. Rolt, Isambard Kingdom Brunel, p. 281.

[95] James Dugan, The Great Iron Ship, pp 15 - 16.

[96] L.T.C. Rolt, Isambard Kingdom Brunel, p. 279.

[97] The Times, "The Leviathan", Issue 22883, Wednesday, Jan 6, 1858, p.11.

[98] The Times, "The Leviathan", Issue 22883, Wednesday, Jan 6, 1858, p.11.

[99] The Times, "The Leviathan", Issue 22884, Thursday, Jan 7, 1858, p.5, The Times, "The Leviathan", Issue 22885, Friday, Jan 8, 1858, p.6, The Times, "The Leviathan", Issue 22887, Monday, Jan 11, 1858, p.7, The Times, "The Leviathan", Issue 22888, Tuesday, Jan 12, 1858, p.6, The Times, "The Leviathan", Issue 22889, Wednesday, Jan 13, 1858, p.8, The Times, "The Leviathan", Issue 22890, Thursday, Jan 14, 1858, p.9, The Times, "The Leviathan", Issue 22891, Friday, Jan 15, 1858, p.6, The Times, "The Leviathan", Issue 22899, Monday, Jan 25, 1858, p.6, The Times, "The Leviathan", Issue 22902, Thursday, Jan 28, 1858, p.6.

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[100] L.T.C. Rolt, in Isambard Kingdom Brunel, p. 281 ,wrongly concludes that "on the 14th of the month, Brunel suspended operations for fear that the high tides of the 19th might float her prematurely." The primary sources, however, indicate that the operation continued until the 28th, see: The Times, "The Leviathan", Issue 22890, Thursday, Jan 14, 1858, p.9.

[101] London Illustrated, "Leviathan" No. 898, Vol. XXXII, Saturday, January 16, 1858, p. 58.

[102] L.T.C. Rolt, Isambard Kingdom Brunel, p. 282.

[103] L.T.C. Rolt, Isambard Kingdom Brunel, p. 284.

[104] The Times, "Floating The Leviathan", Issue 22905, Monday, Feb 1, 1858, p 6.

[105] London Illustrated, "Floating of the Leviathan", No. 902, Vol. XXXII, Saturday, February 6, 1858, p.138.

[106] L.T.C. Rolt, Isambard Kingdom Brunel, p. 286.

[107] L.T.C. Rolt, Isambard Kingdom Brunel, p. 286.

[108] L.T.C. Rolt, Isambard Kingdom Brunel, p. 286.

[109] L.T.C. Rolt, Isambard Kingdom Brunel, p. 288.

[110] L.T.C. Rolt, Isambard Kingdom Brunel, p. 289.

[111] London Illustrated, "The Great Eastern Steamship" No. 987, Vol. XXXV, Saturday, August, 13, 1859, p. 160.

[112] J.C. Horsley quoted by L.T.C. Rolt in Isambard Kingdom Brunel, p. 280.

[113] London Illustrated, "The Great Eastern Steamship" No. 987, Vol. XXXV, Saturday, August, 13, 1859, p. 160.

[114] L.T.C. Rolt, Isambard Kingdom Brunel, p. 290.

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[115] John Pundney, Brunel and His World, p. 112.

[116] James Dugan, The Great Iron Ship, p. 40.

[117] L.T.C. Rolt, Isambard Kingdom Brunel, p. 294.

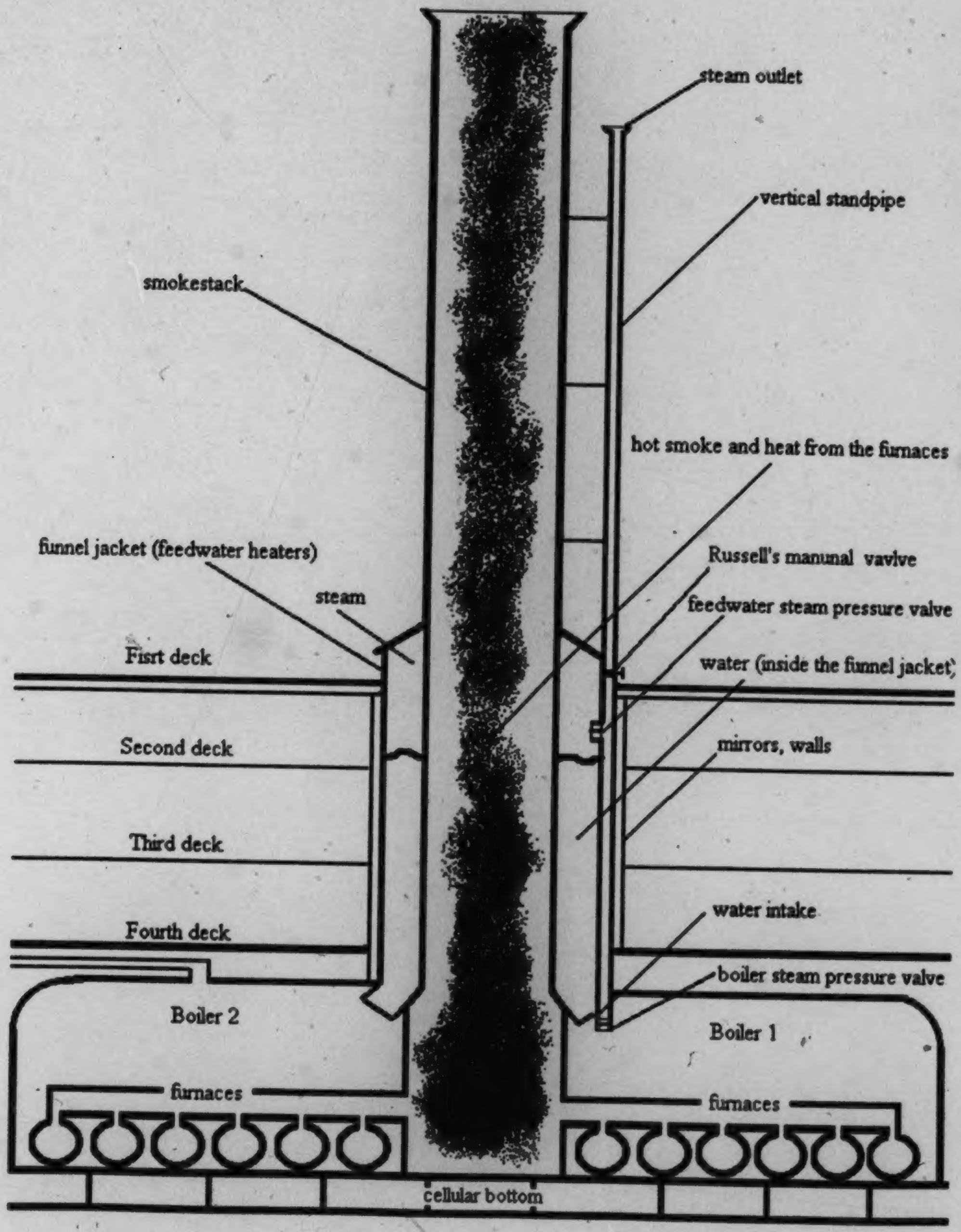
Chapter 4

The Iron Monster

On September 9th, 1859 the *Great Eastern*, without Brunel, began her engine trials, and as the British papers noted, "no ship ever went to sea carrying with her so much of the goodwill and interest of the nation."[1] She was worked up to 13 knots, with her screw engines working at 32 r.p.m, and her paddle engines at 8 r.p.m.[2] A number of important visitors were on the board, as well as Scott Russell and the *Great Eastern*'s commander, Captain William Harrison. He had been chosen above 200 other competitors mostly due to his knowledge of the ship since her unfortunate launch attempts in 1858.[3]

Brunel, after his bad experience with the fire on the *Great Western*, supplied the *Great Eastern* with the feedwater heaters of his own design. These were to serve as the insulators of her five funnels and, at the same time, to preheat the water for the boilers. For this purpose, each funnel was fitted with a double iron jacket at its base, which extended to about 170 cm above the ship's deck. In the jackets the water was preheated and, at the same time, absorbed the heat of the funnels, serving as the heat resistor. Moreover, to prevent the build-up of pressure and steam in these funnel jackets, Brunel designed standpipes extending throughout the height of each funnel. They acted as steam-release mechanisms, each being equipped with a pressure valve [illustration 19]. The design was both safe and very effective. By using one simple device, Brunel solved the problem of the funnels overheating, thus eliminating the danger of fire and, at the same time, decreasing the use of coal. Since the water entering the boilers had

Illustration 19. Transverse section through Brunel's feedwater heater.


steam outlet
vertical standpipe
smokestack
hot smoke and heat from the furnaces
funnel jacket (feedwater heaters)
Russell's manunal vavlve
steam
feedwater steam pressure valve
Fisrt deck
water (inside the funnel jacket)
Second deck
mirrors, walls
Third deck
water intake
Fourth deck
boiler steam pressure valve
Boiler 2
Boiler 1
furnaces
furnaces
cellular bottom

already been preheated in the funnel jackets, less coal was needed to keep it at the boiling point. However, the passengers on board, as well as the ship's constructors, were unaware that two of the five feedwater heaters' standpipes were closed off and that an immense pressure was building up in the funnel jackets as the ship steamed towards Hastings. Brunel's design had called for the standpipes to have open outlets at all times, so that the pressure valves could release the steam, but when Scott Russell preformed pressure tests on his paddle engines, he altered Brunel's invention by bypassing the pressure valves and installing manual valves on the standpipes above them. Three had been removed after the tests, but two above the paddle engines had not and for unknown reasons remained closed. The negligence of Russell, who was responsible for this part of the ship, was such that the two valves were also covered with wooden casings. The valves were placed just above the deck and were entirely inaccessible from the boiler room and hidden from view. L.T.C. Rolt, maintains that what followed was thus entirely the result of Russell's negligence.[4]

As the guests admired the elaborate decorations of the *Great Eastern*'s main saloon, the pressure was rising rapidly behind the huge mirrors that covered the lower portion of the funnel jacket [illustration 20]. Although Rolt claims that " Mercifully, everyone had left the salon before the explosion occurred,"[5] Captain Harrison's daughter was still in the salon when the explosion took place.[6] The rest of the passengers were likely in the dining saloon and on the bow of the ship, observing the view of Hastings, when at 6:05 pm, just as the *Great Eastern* was passing the Dungeness Light,[7] an immense explosion shocked the ship [illustration 21]. No previous historian has noticed an interesting coincidence. The last picture of Brunel,

Illustration 20. The grand saloon of the Great Eastern, 1861.

Illustration 21. The torn funnel jacket on deck of the Great Eastern, 1859.

taken just moments before his stroke, was taken in front of the feedwater heaters (the funnel jacket is clearly visible), and more strikingly, the small vertical pipe (the standpipe) which was closed off by Russell's valve and caused the explosion, is clearly visible next to him [illustration 18]. The *Times* reporter present on the board when the explosion took place wrote:

> The forward part of the deck appeared to spring like a mine, blowing the funnel up into the air. There was a confused roar amid which came the awful crash of timber and iron mingled together in frightful uproar and then all was hidden in a rush of steam. Blinded and almost stunned by the overwhelming concussion, those on the bridge stood motionless in the white vapor till they were reminded of the necessity of seeking shelter by the shower of wreck – glass, gilt work, saloon ornaments and pieces of wood which began to fall like rain in all directions.[8]

As a result of the explosion, the saloon's decorations and mirrors were destroyed, and the paddle engines' boiler room was filled with boiling steam, which caused serious burns to those working in there. "None who had ever seen blown-up men before could fail to know at a glance some had only two or three hours to live…"[9] said an eyewitness, further noting, "One man [most likely a fireman named McIlroy] walked along and seemed unconscious that the flesh of his thighs was burnt to deep holes. He said quietly, 'I am all right, there are others worse than me, so look after them.' "[10] He died shortly afterwards. Two other firemen, Adams and Mahon,[11] died as a result of extensive burns, while a trimmer named O'Gorman,[12] heavily burned, jumped into the water and died after being caught by the gigantic paddle wheel. Two more men, Adams (a second man with this name) and Edwards, died the next day from their serious burns. Captain Harrison's daughter, who was the only person present at the core of the explosion, was found alive, having being saved by a bulkhead. Thus, a total of six men died that day as a result of the explosion, but the danger was far from over.

The build-up of pressure in the first funnel jacked, which had caused the explosion, was still gathering in the second funnel, which also had a closed valve in the standpipe. No one can explain how the second feedwater heater withstood the pressure, even though the first one did not. Also, no one ever explained why, shortly after the explosion, the engineer in charge of the paddle engines, Arnott, issued a valve key to a greaser named Patrick,[13] who was ordered to open the second standpipe valve just before it exploded.

The *Great Eastern* was almost intact, for the iron bulkheads had confined the explosion to the grand saloon, and the ship's course was not altered. The explosion proved that Brunel's design was superb in its strength and safety, but six men died and for this reason, the accident was a disaster, as Rolt noted:

> Brunel's design seemed fated to be subjected to ordeals occasioned through no fault on the part of their creator. That they could survive them at all was an engineering triumph, but from every other point of view these ordeals were unmitigated disasters.[14]

In the evening, the *Great Eastern* steamed into Portland Bill. All the sources indicated that "no other ship could survive such an explosion"[15] and then steam on her own to safety. The explosion proved that Brunel's ship was an engineering success. Her rib-less design was much stronger than anticipated. The explosion was not regarded as a disaster, but rather as a demonstration of the ship's strength and safety, as the *London Illustrated* indicates:

> So entirely is the public attention fixed upon the progress of the Great Eastern that the terrible explosion of Hastings may be scarcely said to have surrounded her with more rational interest than was linked with her fortunes from the moment that her paddles first churned the waters of the Thames. Not even the ominously bad news from China, or the daily-increasing complications of European policy, are sufficient to distort attention from her fate and her achievements.... Like the old mythological heroes, she is ushered into the

> world amid signs and portents. Omens both good and of evil have surrounded and followed her from her first conception. Every incident in her career has partaken of the grand and the poetical. There is an epic sublimity in all that relates to her, such as befits of Titan of the Deep. Difficulties, pecuniary, physical and moral, have beset her from the first. She has had to struggle against evil tongues and evil fortunes. But she has silenced the one and triumphed over the other. The every elements and powers of nature seen to have revolved against her only to be conquered and brought into subjection. The difficulties of her launch threatened at one time to be fatal to the whole enterprise; but skill, courage, and perseverance overcame them all.... Suddenly, and at a moment when no one suspected evil, when the storm had swept over her pathway, and made no perceptible difference in her motion, and when all was merriment and rejoicing on board, danger came in new shape. [An] explosion ensued which would have been the utter destruction of nay other ship which ever followed, but which in the case of the Great Eastern only proved how superior she is to the ordinary, or even extraordinary, casualties of steam navigation.[16]

Afterwards, "the toppled funnel was purchased by the Weymouth Waterworks Company and buried in concrete at the bottom of the deep end of the Sutton Poyntz dam as a strainer shaft for the local water supply. It is still there."[17] Although the ship survived the immense explosion and the event was regarded as proof of her future success rather than failure, Brunel's heart failed after the news of the explosion was brought to him.[18] The *London Illustrated* reported:

> Mr. Brunel was on board the Great Eastern (his last important work) on the day before the vessel left the Thames, and remained for several hours to witness the trial of the engines. Symptoms of paralysis showed themselves, and he was hurried home, and laid on the bed from which he never rose again. The news of explosion on board the great ship reached him on Thursday last, and from that time he gradually sank until Thursday night, the 15th, when he expired, in his fifty-fourth year.[19]

As well, Daniel Gooch, Brunel's close friend, and, until his last days, a strong promoter of the *Great Eastern*, wrote:

> By his death the greatest of England's engineers was lost, the man with the greatest originality of thought and power of execution, bold in his plans but right. The commercial world thought him extravagant; but although he was so,

> great things are not done by those who sit down and count the cost of every thought and act.[20]

The completion of the *Great Eastern* and the struggles with Scott Russell, which forced Brunel to work continuously, added to his sudden death. He was one of the greatest engineers, and his ability to convince others about the rightness of his plans was truly amazing. Brunel devoted the last years of his life to the great ship, and his entire life to his profession. Most of his contemporaries regarded him as a great man, and he was generally known as 'the Little Giant.' However, what made him great was neither his gigantic ships, nor the daring deep tunnels he dug under rivers and mountains, but his devotion to and love for his profession. The *Great Eastern* became the final monument to this extraordinary engineer not because of its size but because almost every part and every blueprint of the ship carried with them a part of Brunel's character and his engineering genius. In the light of what was to follow, it is important to note that the *Great Eastern* was almost entirely Brunel's idea and, as we have seen, he was main driving force for the ship's construction, launching, and, finally, outfitting. However, just before his fatal stroke knocked him down, the visitors to the great ship were informed that "the merit of the construction of the ship and her successful completion is owing entirely to the untiring energy and skill of Mr Scott Russell."[21] From the start, as we have seen, Russell regarded Brunel as his rival and enemy, whereas Brunel, for far too long, regarded Russell as his friend.[22]

The events that occurred shortly after Brunel's death made Russell's negative impact on the ship's career even more apparent. As the great engineer's body was being prepared for his last journey on September 19th to Kensal Green, Russell boldly announced in court that "the feedwater heaters were not of his design but were a modification which did not appear on his original detailed drawings of the ship…"; thus, he was not responsible for the explosion. We might never know for certain how much he was responsible for the explosion, but the enquiry performed after the accident, on September 19th, indicated something that historians have never noted, the possibility that either Russell or one of his employees, might have deliberately caused the explosion.

During the court hearings, an engineer named Duncan McFarlane, whom Russell had placed in charge of the engines, testified that the two valves had been open prior to the departure from the Nore.[23] This testimony suggests that someone may have purposely closed the valves to create the explosion later on during the trip. Two facts further strengthen this theory. First, if McFarlane were lying, as Russell argued in the court, and had simply neglected his duties, the explosion should have occurred much earlier. Given the thickness of the funnel's iron walls, the time, and the steady increase in pressure, the funnel jackets almost certainly could not have withstood such force until the ship reached Dungeness Light. Since the explosion had not occurred much earlier than it actually did, the events support McFarlane's statement that "two valves were open at the Nore and that in proof of this he had seen steam issuing from the mouths of the standpipes."[24]

The second fact pointing to the possible deliberate cause of the explosion is the testimony of Arnott, who, also nominated by Russell, was the chef engineer of the engines. He testified that he had never issued an order to open the valve, nor had issued the key to the wooden casting which hide the valve.[25] This claim contradicted the statement of the greaser Patrick and the events that followed. As was mentioned, Patrick opened the second valve and testified that he had done so under the orders of Arnott. If Patrick were lying, how could a simple worker access the valve without having a key, know its location, or that this was the cause of the first explosion moments after the event? Arnott's testimony suggests his possible direct involvement in the explosion. For if he would testify that he had given Patrick the key, it would mean that Arnott had known what had caused the first explosion. The logical question that a judge and the public should have asked in such a case should have been why he had not opened the first valve and thus prevented the explosion. His testimony indicates that he probably knew that the valves were closed and that by denying that he had issued a key to Patrick, he hoped to clear himself and Russell from allegations of responsibility. However, Arnott never explained how Patrick had gained the access to the valve and how he could have known that it had been responsible for the explosion. Arnott's testimony, in fact, caused a sensation in the court, as the *Times* indicated: "The reluctance with which the witness gave evidence caused a sensation in the court…."[26] Despite all the evidence, Russell was never officially accused of causing the accident. Moreover, to the outrage of Brunel's friends, Russell was given the contracts to repair the ship after the explosion[27] and also took Brunel's place as the company's engineer.[28]

The *Great Eastern*'s history continued to be full of misfortunes and struggles against the elements of nature, which the ship withstood, demonstrating the durability and supremacy of Brunel's design long after his death. Since the misfortunes of the great ship were almost countless, we will concentrate only on the major ones that affected directly the ship's career. First, Scott Russell, the man who had caused so many delays, contributed to the failure to launch the great ship on time, and possibly been indirectly responsible for Brunel's early death, was once more in charge of the work on the ship. This fact had major negative consequences and directly contributed to the ship's failure to become an ocean liner. Russell was given the contracts after refusing to pay for the damage caused by his engineering negligence. Moreover, he estimated that he could repair the ship in only three weeks for the sum of £5000.[29] Given that Russell had made so many false promises, the directors' decision is difficult to understand. In any case, the company advertised that the *Great Eastern*'s maiden voyage to New York would begin on October 8.[30] Meanwhile, the ship was opened to the public. Some 6000 came to see her being repaired after the explosion and provided £120 for the families of the victims.[31]

As had occurred previously, Russell's deadline passed while his work was still very far from being finished. Consequently, the *Great Eastern* did not sail to America on October 8, and her passengers, after waiting ten more days, demanded their money back.[32] Because of Russell's miscalculations and lack of progress, "the big ship was losing her identity as a passenger vessel."[33] When the grand saloon was finally renovated, the ship, due to the coming winter, was unable to sail and was moved to Holyhead where she was put on display. Thus, no trip to America was attempted in 1859, for the winter came before she was ready to sail. On her way to Holyhead, a crewmember named McGrogan was killed when the gigantic paddle engine torn his head off.[34] He was the 12th victim of the ship, excluding Brunel, and was not to be the last one.

As the ship was moored at Holyhead, the extraordinary storm known as 'the Royal Charter Storm' caused the *Great Eastern* to loose her mooring chains and be set adrift in what was to be one of the worst storms in Britain's history. Regular-sized ships were being sunk all around the *Great Eastern*, but due to her design and size, she, although adrift, survived the strongest winds and outlived many other ships that went down that day. The most tragic loss during the storm was the end of the *Royal Charter*, which was wrecked nearby with the loss of 446 people and some $3,750,000 (£75,000) in gold. Most of the reasons for the *Great Eastern*'s survival must be attributed to her colossal design and also to Captain Harrison and the chief of the paddle engines, Alexander McLennan. They managed to engage the paddle wheels and keep the ship facing into the wind and waves, thus preventing her from being pushed onto the shore and wrecked. The *Great Eastern* survived, but her grand saloon had been devastated again. This time, the interior was heavily damaged by the water and wind that had come through her shattered skylights during the storm. As a result of all these misfortunes, the second owners were faced with bankruptcy. The ship had cost them £1,000,000, and they had a bank balance of about £1100.[35] They tried to obtain a government subsidy but were unsuccessful, and the company was once again in state of financial disaster. Moreover, the ship's ill fortune had demonstrated itself in what was to be an unprecedented event in maritime history.

As the *Great Eastern* was being moved to Southampton for the winter, after the Royal Charter Storm, Captain Harrison, the ship's surgeon, 7 crew members, and the nine-year-old son of Captain Lay were leaving the ship in a sailboat. The boat's sail seized, and a strong gust of wind caused the boat to capsize. Tragically, a crewmember, Captain Lay's son, and Captain Harrison, the master of the *Great Eastern,* were killed. The gigantic ship had claimed 15 casualties so far, without having carried a single paying passenger.

James Dugan claimed that the ship's unbelievable bad luck could be attributed to the missing basher boy: "A ghost story fastened to the great ship: that a riveter had been sealed up alive in one of the hull cells.... His spook was said to have jinxed the ship."[36] It is thus no wonder that the ship gained a bad reputation. As a result of the tragic death of Captain Harrison, the second owners of the *Great Eastern* resigned, being overwhelmed by the great ship's misfortunes.

The third company of owners, led by Brunel's friend Daniel Gooch, was determinated to make the *Great Eastern* profitable and to restore the public's confidence in her. They issued 20,000 shares, at £5 each, giving the company £100,000 in capital. The new directors, particularly, Brunel's friends, managed finally to remove Scott Russell from the project. The new company's first official action was to discharge Russell from his position as the company's engineer and, further, to forbid him to enter the ship. The *Great Eastern* seemed to off to an auspicious start, and with the company's money problems solved and her repairs completed, she had a good chance of becoming a successful ocean liner. However, her bad reputation and all the previous delays involving the ship had caused irreversible damage to her image. Consequently, on *Great Eastern*'s maiden voyage to New York, only 35 paying passengers were on board, far less than were needed to make her a successful passenger vessel.

The ship sailed from Southampton for New York on June 17, 1860, carrying 418 crewmembers, 8 company officials including Gooch and his family, 35 passengers, and a load of London Club Sauce.[37] John Vine Hall, who had replaced Captain Harrison, was the *Great Eastern's* new captain. The trip was to be her first ocean trial and was regarded as an event without precedence in history:

> [When] the monster struck for the New World it was the final embarkation, the real trial trip, the first ocean voyage of a ship that has been the parent of more talk, speculation and wonder, and worldwide interest, than any craft since Noah's Ark.[38]

The voyage across the ocean went well without a single mishap. The ship, however, rolled as much as eighteen degrees in heavy winds.[39] This problem, fortunately, did not cause any damage, and none of the passengers reported that the *Great Eastern*'s rolling had caused them to be seasick.[40]

On June 28, Brunel's ship reached New York, eleven days after leaving Southampton. New York was expecting her, and thousands came by boats to look at the monster and to welcome her, as she waited for the full moon's tide, to enter the port. The Americans were in a state of *Great Eastern* mania; even the visit of the Japanese ambassador was eclipsed by her, as the *Herald* indicated: "Her gigantic shadow is quivering in the waters, and before another sun has set our Oriental friends will be almost forgotten."[41] Hundreds of little boats and ships surrounded her, while at 2 pm, she made her way towards New York harbour. Daniel Gooch noted in his journal that "every spot where a human being could stand [was occupied by people]."[42] Her pier extended from West Eleventh Street to West Twelfth, for after the ship was completed, she was never berthed, but was always moored away from shore. Mooring her in this way presented a challenge, for her enormous side wheels made safe side-docking impossible. As the ship approached the wharf and the mooring lines were dropped from above, the crowd seized them and pulled the ship towards the pier. Consequently, the side wheel hit the lumber wharf and crashed some 1.5 meters into the pier before being disengaged. Luckily, no one was killed, but the ship suffered light damage to her paddle box. In Brunel's original design, as was mentioned previously, the ship was equipped with two smaller steamers and was not designed to be moored at a pier. The two smaller ships were to move the cargo and the passengers back and forth; thus, the accident did not occur because Brunel had designed the ship inadequately, but rather because his original design had been altered. After the ship was successfully moored, "the passengers came ashore and were nearly mobbed by admirers. The 'immortals' were caught there until dark before their baggage was got ashore."[43] On the following day, New Yorkers turned the site into a folk fair. The number of people who came to admire the ship was overwhelming and reported to have been over 500,000.[44] The best evidence of what a sensation the *Great Eastern* was is that her admirers created such an enormous cloud of dust that Gooch was forced to close the ship for five days to have it cleaned and repainted. During these five days, the great ship claimed six more victims. First, Thomas Leavitt was sent to examine the side wheel and during his inspection, fell overboard and died. One sailor died by slipping overboard. His body was found when the ship left and the paddle wheel brought his corpse up to the surface. Moreover, two sailors died by falling through an open hatch, one died in the boiler room, and one was killed in a fight on the ship.[45]

On July 3rd, the monster was opened to the eager public, but the one-dollar admission greatly limited the number of guests, and only 1500 came the first day and on

July 4, 2000 more, so the profit was only about £700. The ship lost some of her fittings, and the visitors stole an oil painting from her grand saloon. After one week of growing anger because of the high ticket prices, the company agreed to drop the price to 50 cents. Consequently, in the following four weeks, 143,764 tickets were sold.[46] At the end of July, the directors decided to sell tickets for a two-day cruise to Cape May, at $10 per ticket. As 2000 tickets were sold, earning some £4000, the trip seemed to be a success, but what followed would ruin the positive image that the *Great Eastern* had gained with the American public.

The *Great Eastern*, carrying over 2500 people, proved to be entirely unfitted for passenger service. Due to financial problems, Brunel's entire design had never been carried out, and although "she [was] designed to carry eight hundred first-class, two thousand second class and one thousand and two hundred third class passengers…"[47], with a ship's company totaling four thousand and four hundred people, only three hundred beds had been installed for the passengers. The Americans, unable to go to sleeping cabins, were forced to spend the night on the deck. Some of the main things that went wrong that night and the next day after included the entire crew's drunkenness and misbehavior; the lack of any attendance to the passengers; the lack of food, drinking water, warm water, and toilets; and even the abduction of women. Although some lucky passengers managed to get mattresses, these passengers' 'comfort' proved to be short-lived, for the crew stole them and then demanded money in exchange.[48] All these problems, plus the fact that in the morning, a rain of cinders from the *Great Eastern*'s five funnels 'welcomed' the sleeping passengers, greatly added to the disaster that followed.

Exhausted, dirty, hungry and wet from the morning rain, the passengers went for breakfast, but non was served because the last dinner had used up the ship's entire food supply; consequently, the launch was also foodless. Suffering from hunger and exhaustion, the American reporters present on board called a passengers' meeting, which one reporter summarized: "I can not now bethink of a single means for annoying man, woman or child on a voyage of pleasure that these imperious gentlemen [the crew of the ship] left untried."[49] Everyone appeared to want to be the first to disembark from the ship, and she was scheduled to reach Old Point in the early morning. Thus, an outburst of outrage and anger occurred when the American passengers discovered that no land was to be seen after they had awakened. As it turned out, during the night the *Great Eastern* had gone off course and sailed some 100 miles into the open ocean. When the ship finally arrived in the afternoon at her destination, 70 passengers jumped into the water, unwilling to stay on the ship any longer. One man was reported to be so desperate that he jumped from the paddle box, a height of 14 meters: "he reappeared and swam to the sponson ladder, dispelling the suspicion that he had chosen self-destruction as a reply to the *Great Eastern* directors…."[50] This report is not believable. Most likely, the man fell by accident, but this event certainly added to the bad reputation that the ship gained after that trip. As result of these dramatic events, the *New York Times* wrote: "The *Great Eastern* has returned to the city and is advertised to start immediately for Annapolis Roads. Don't go."[51] Even if the events were exaggerated, and some probably entirely made up by the angry press, the great ship lost its good reputation, and consequently, her next trip at $8 a ticket attracted only 100 paying passengers. This was more successful than her first one because her speed was recorded at 15 knots, making her the fastest steamer in the world. However, the damage done by the American press, and the obvious misbehavior and mismanagement of the ship's crew, proved to be irreversible. *Harper's Weekly* stated:

> In a few days the *Great Eastern* will take her departure. She has certainly attracted a great deal of attention, more than any other ship that has ever anchored in the Bay of New York. At the same time it would not be correct to say she has been a success, or that we part with her with very much regret. [The managers were] grossly inefficient, the ship dirty, the officers and crew discourteous and rude.... [52]

The *Great Eastern* while in America for two months made $120,000 (£24,000); the cost of the trip and the expenses was about $72,000 (£14,400), and the interest on the investment in her was $5000 (£1000) a day (totaling about $300,000 (£60,000) for two months). As a result, the American trip turned out to be a complete financial disaster and ruined the ship's third company of owners. Just before the ship was to leave New York, the ship's propeller shaft was discovered to have worn out and need repairs. The directors could not afford them, and the ship sailed, damaged, with only 100 passengers to Halifax. No crowds waved goodbye as she was departing from New York.

Gooch believed that Halifax was a much better place for the great ship, thinking that the locals were much better behaved than the Americans were.[53] However, the practice in Halifax was to base the harbour dues on a ship's tonnage. The *Great Eastern,* being by far the biggest vessel in the world, was extremely heavily taxed ($1750) before she was allowed to enter the port. The city's governor refused to share this cost, and Gooch, offended, turned the ship around and made for England the next morning, without admitting a single guest.[54] On the ship's way home, the screw shaft finally gave out. James Dugan claimed that the ship's sails were used at that point and that the repairs were done with both her engines shut down.[55] This claim seems improbable, given that she set a new world record for speed on that voyage, crossing the Atlantic in only 9 days and 4 hours. She was warmly welcomed in Milford Haven,[56] and the return trip was in every way a success; Brunel's design was finally proven to have resulted in the construction of the fastest steamship in the world, and her safety was also confirmed, as she was able to reach England with her screw malfunctioning.

The *Great Eastern* was, however, unfit to serve on the cold North Atlantic, for as she had been designed to travel to Australia and India, the great ship had no heating system. Her iron hull was too cold for the passengers or the crew, and the company was in state of financial ruin and could not afford to outfit her properly. Consequently, she had to wait until the spring of the following year to sail again.

The ship was preparing for her second voyage to New York in April 1861. At this point, Scott Russell again entered the great ship's story. He demanded that $120, 000 (£24,000) be paid to him for building costs, and the court ordered the company to pay the full amount. The ship was scheduled to sail for America on May 1, on the same day that Russell announced his victory in the court.[57] One hundred passengers were already on board. Russell did not agree to the directors' plea to let the ship sail and allow them to pay him when they returned with money made in America. The company was thus forced to fire 6 out of 10 officers, and about 150 crewmembers, to pay the first down payment to Russell.[58] As a result, the ship's captain, Carnegie, refused to sail and was replaced by Captain William Thompson. Thus, Russell had managed again to delay the *Great Eastern*'s departure and thus greatly contributed to her loss of passengers. It is worth noting, since Scott Russell played such an important role in the *Great Eastern*'s history, that finally in 1866, for the same kind of money mismanagement that he had demonstrated during the great ship's construction, he was permanently removed from the Council of Civil Engineering.[59]

The voyage to New York took 9 days and 13 hours. The ship encountered a huge storm on her way, but she survived it without any serious damage, and one crewmember suffered a broken leg.[60] After this storm, a *Times* reporter wrote: " The ship may never again encounter such a gale. If she ever does she will meet it on fairer terms."[61] Her second visit to New York did not cause much attention, as the Civil War, which had begun a month earlier, was occupying the minds of New Yorkers. The ship's directors decided not to admit the public to the ship. Only on the last days of her stay in New York was the public admitted at 25 cents a ticket, but not many people were interested. The ship sailed for Liverpool with 194 passengers and 5000 tons of American wheat on board, the biggest load carried on one ship.[62] The Civil War presented a great opportunity for the *Great Eastern*. As the largest vessel in the world, she was finally recognized as a valuable troop carrier, and Brunel's dream of the ship being able to carry her own coal supply and thousands of passengers across the ocean almost came true.

The British War Office decided to charter the *Great Eastern* to carry large numbers of troops to Canada. With 400 crewmembers and over 3000 troops, the *Great Eastern,* commanded by Captain James Kennedy, sailed for Quebec City in July 1861. This voyage was the first and the last time that the great ship carried so many passengers. The crossing was a tremendous success for it. Almost fully loaded, the *Great Eastern* set a new world's record, arriving in Canada after 8 days and 6 hours. However, the ship claimed her 22nd victim, as a sailor was killed after falling from the deck. Nevertheless, the great ship was finally successful, and on her way back, she carried 356 passengers to Liverpool.[63] Unfortunately for the *Great Eastern*'s owners and the ship, when she returned to England, the government terminated the owners' charter. Consequently, the monster was once again prepared for a voyage to New York.

The most convincing proof of the safety and success of Brunel's design came with his ship's third trip to New York in 1861. The ship, after returning from Canada, regained the confidence of the British public, and a record number of 400 paying passengers boarded her at Liverpool. Ten days before, the experienced Captain James Walker from the Cunard Line was appointed as her new captain. As she was leaving Liverpool on September 10, 1861, with the 832 people on board, over 300,000 locals showed up to witness her departure, demonstrating that she was still a sensation.[64] In the evening of the second day, she passed the Fastnet Light, the last visible indication of land in Britain. The next morning on September 13th, the weather turned into a heavy storm. The ship's logbook recorded that at 4 pm, the *Great Eastern* was some 300 miles west from the coast of Ireland, when the winds turned from heavy to hurricane force.[65] The great ship, steady up until then, began to roll heavily, and as the growing gigantic waves began to reach the ship's deck, the passengers could no longer remain there. Later, one passenger wrote in his journal, "I now begin to understand the true meaning of a gale in the Atlantic. The Captain looks anxious, but the passengers have faith in the big ship. None but experienced persons can walk about."[66] In matter of hours, even the sailors could not "walk about", as the journal of another passenger indicates: "The waves were as high as Primorose Hill. Even the oldest sailors could not get their sea legs."[67] As the storm grew, one of the high waves crashing on the bridge carried

Captain Walker from his post, and, most likely, the same wave hit the paddle wheel casting, which bent inwards and hit the four-meter-wide wooden wheel floats. Consequently, the gigantic floats were splintered into pieces. Captain Walker managed to make his way towards the bridge and ordered the paddle engines to stop, but the wheel had already lost its floats. As Scott Russell's engines were shut down, the cargo on board the great ship, due to heavy rolling of the vessel, came loose. Hundreds of gallons of fish oil spilled and added to the agony of the passengers and crew: "During the coming days of the ordeal the smell of fish oil was so compounded with storm terror that the survivors could never again smell the stuff without feeling the agony of the *Great Eastern*."[68] As the storm reached full hurricane force, James Watt's screw engines proved inadequate to keep her heading straight into the storm. This problem proves the point that one propulsion system was inadequate for moving the great ship across the ocean; once her side wheels were disengaged, she could not make any progress and was slowly and dangerously exposing her side to the wind. Once a ship cannot remain straight and facing the wind and waves, she has almost no chance of survival. One of two possibilities usually follows. Once one of a ship's sides is exposed to the wind, the waves cause the ship to capsize, or it takes a nosedive. A captain's priority in such a situation is always to save the ship by bringing her back towards the wind and taking the waves on the bow, and to prevent at any cost her becoming sideways to the storm. Hence, when the *Great Eastern* began to increasingly expose her side to the wind, she was dangerously bringing herself closer to destruction.

The screw alone was unable to keep her heading straight, and the great ship eventually gave in to the forces of nature, exposing her entire port side to the gigantic waves. The consequences were disastrous. The port side was crushed by incoming waves. The left side wheel ceased to exist, for it was stripped to its bare frame.[69] The next waves took most of the *Great Eastern*'s lifeboats. The remaining ones on the ship's starboard side were knocked out of their davits, and one of them, boat number five, was left hanging downwards at the front of the right side wheel. Captain Walker, desperate to save the remaining wheel, ordered the lifeboat cut loose, and at the same time, he reversed the screw and the remaining paddle wheel. The maneuver worked, and the wheel was saved, as the boat was carried away from the wheel. As a consequence of this accident, the captain ordered all lifeboats to be cut loose, leaving the passengers without any hope of abandoning ship. (The lifeboats could not have been used in such a storm, so Captain Walker's decision was in every respect justifiable.) Now without her lifeboats and heavily damaged, and exposing her side to the storm while rolling at an angle of as much as 45 degrees,[70] the *Great Eastern* had a slim chance of surviving much longer. Her captain must have been well aware of the danger, and as the ship's logbook indicates, he gathered all the power he could to try bring the ship back into the wind. [71] As Captain Walker and the crew prepared to engage both engines, one gigantic wave crushed and carried away the starboard wheel; with it, the last hope of using the paddle wheels was gone.

The *Great Eastern* was shortly to be exposed to even more damage. After the paddle power was lost, the captain ordered the screw to be reversed and the rudder turned so that the ship could back up into the wind. During this maneuver, a wave hit the gigantic rudder, and its 26-cm-thick iron column broke just above its bearing. The ship lost her steering. Moreover, the rudder, now hanging loosely from its shaft, was moved freely by the incoming waves and started to hit the blades of the revolving screw. The screw engines thus had to be disengaged, and the *Great Eastern,* with her engines dead, rudder damaged, and lifeboats gone, had only one last chance of survival, her sails. The captain ordered the sail's engines engaged[72] to bring the sails up, but before they were hoisted, the canvas was ripped into pieces. The ship was now out of control, and the crew or the captain could do little more than, wait for their end or for the storm to pass.

On only the first day of the storm, the ship's surgeon, Dr. Watson, treated some 27 major fractures,[73] and the ship's interior was ruined when the water burst through the broken skylights. As the night approached, one of the passengers wrote: "May the Great Ruler of the Waves have mercy upon us this night."[74] The next day brought no improvement in the weather, but the ship had survived the night. The only way to save her was to repair the damaged rudder and to try to engage the screw engines. One of the passengers, a young engineer named Hamilton E. Towle, designed a system of blocks and chains to control the damaged rudder, but the captain rejected the proposal. A passenger named Forwood described the situation on board:

> The scene defies all description. Water has got in to float even the larger articles. The rocking of the ship has set the whole mass in motion. Friction has reduced portmanteaus, hat-boxes, dressing cases, and all the personal chattels of four hundred passengers into mass of pulp. Here are the spangles of the dress of an actress, and the sleeves of an officer's coat, the rim of a hat and the leg of a dress boot. I see men feeling cautiously with their bare feet for jewels and money in which this desolation is said to be rich. How they will identify their own and resist the temptation of taking that which is not theirs is beyond my philosophy.[75]

Perhaps the best indication of the ship's true position was that on the second night, Captain Walker announced to the passengers: "Gentlemen, I have a mutiny on my hands…"[76] as the crew had decided to "enjoy final comforts before they departed this world".[77] By the third day, the grand saloon was completely ruined, and water was present everywhere on the ship, but the pumps were still working, and the ship was not sinking. The twelve watertight compartments designed by Brunel had worked. For a moment, there was a hope of rescue when a small brig, the *Magnet* of Nova Scotia, sailed near the *Great Eastern*. The *Magnet* tried to sail around the ship, but without any hope of rescuing the 832 souls on the great ship and risking her own life and cargo, she was forced to leave.[78] As night approached, she sailed away. At this point, the passengers lost any hope of rescue by another ship, and Hamilton E. Towle persuaded Captain Walker to let him utilize his plan.

The task was difficult, for the rudder was moving uncontrolled with great force, but the crew succeeded in putting chains around the broken shaft and, by using blocks, securing it in one position so that the screw could be engaged. For reasons unknown, the *Great Eastern*'s chief engineer, Robinson, refused to use the already installed device and wasted valuable time trying to fix the rudder from the outside.[79] These attempts failed, and when the next morning arrived and the storm had decreased, the captain ordered the screw engines to be engaged. Towle's device worked. At 5 pm, Sunday, the *Great Eastern* steamed at a speed of 8 knots per hour towards Cape Clear, Ireland.[80]

Without propulsion or steering, the ship had survived for three days in hurricane-force winds on the open sea, most of the time side-on to the waves. Her survival was by far the greatest proof that Brunel's design was, in fact, in every way successful. The storm once more regained its strength as the *Great Eastern* was approaching Ireland, and consequently, she was unable to access the harbour for another three days. As the great ship was finally towed to safety at port, her quartermaster was hit by the steering wheel in the head and died instantly, becoming the ship's 23rd victim. The surviving passengers "went ashore at last, with unanimous resolutions thanking God, Captain Walker, Hamilton E. Towle."[81] The *Great Eastern* had been heavily damaged once again and required expensive repairs that put her out of service until the next season.

Nevertheless, David Gooch was convinced that the *Great Eastern*, once repaired, would finally pay off, but her ill fortune was to strike again, and this time from underwater. Gooch raised all the money he could to pay the passengers for their losses. The great ship swallowed another £60,000, which was required to make her seaworthy. Some improvements were made to the rudder mechanism and the side wheels. The rudder was equipped with an emergency steering device, and the side wheels were made stronger and smaller by 2 meters in diameter.

As well, the ship had gained some good publicity after surviving the storm, as James Dugan indicated: "The ship had won universal tributes for her victory over the storm… and hope still throbbed in the breasts of the directors."[82] Moreover, the ship had gained a new, devoted, and well-behaved crew, commanded by Captain Walter Paton. He was one of the first captains who had gained his experience and built his career entirely on steamships. Thus, he had a great knowledge of steam navigation and was as much interested in the crew as in the engines. He was aware that men were as vital to ship's success as the machinery.[83] At last, the *Great Eastern* appeared to have a good chance for success, but the situation on the oceans was drastically different from that in 1850's:

> Starling changes had come to the North Atlantic tracks.... During the fifties the American merchant marine persisted in its romantic obsession with wooden clippers, a dream loomed in bright threads as the clippers raced around the Horn to the goldfields of California. The money was in the speed. There was no thought of schedules and economical capacity.[84]

Up until 1850's, the clippers were by far faster than any steamers, capable of reaching 17 knots per hour and requiring no expensive coal. The Americans believed them to be the way of the future in maritime design. They proved, however, highly unpredictable, and when they sank usually there were no survivors, as these ships had been designed for speed and not for safety. The British took a different approach to maritime design, investing in fleets of small side-wheelers, slowly traveling on regular schedules, and more predictable, safer, and by far more luxurious even for the lowest class of travelers. These ships, operated by the Cunard and Inman Line, dominated world travel in the 1860's. The *Great Eastern,* thus, was somehow stuck between the two decades; she was as fast as a clipper, safer than any steamer, yet she was completely unpredictable, due to her constant mishaps and bad management. Consequently, when she sailed for the fourth time to New York after being repaired, in May 1862, only 138 passengers were on board. Although James Dugan claimed, "When one analyzes the many reasons why the *Great Eastern* failed, the incredible refusal to carry emigrants counts as much as any other,"[85] the true reason why she carried so few third-class passengers was probably that no emigrants wanted to make the trip on the great ship, even though they had no pragmatic reason for not wanting to travel on her. A trip on the *Great Eastern* cost only £6-£10 for the third-class passengers, while on one of the Cunard's ships, the cost was between £12 and £18.[86] The "incredible refusal" of the ship's directors to carry passengers was not the problem, for the emigrants chose, for reasons unknown, to travel on more expensive ships. The only possible reason for this choice was that the ship was considered unpredictable, and this factor must have greatly contributed to the lack of passengers on the great ship's fourth voyage to New York.

The *Great Eastern* arrived in America for the third time on May 17 and was again opened to the public. The new crew and the captain were very different from those of 1860, and the great ship regained some of Americans' trust and respect. Consequently, 700 passengers bought tickets for the return trip to England, 400 first class and 300 steerage. The ship also carried some 3000 tons of cargo.[87] The *Great Eastern* earned $125,000 (£25,000) and appeared to be finally slowly paying off. Then, Hamilton E. Towle reentered the ship's history, as two days before she was to depart, he filed a claim for the salvage money because his device had saved the ship. The estimate was $100,000 (£20,000), and the ship was unable to leave unless this sum was paid. The *Great Eastern*'s owners had no choice: they paid $ 10,000 (£2000), and the ship sailed away on time.

The voyage proved to be a tremendous success. Captain Paton was able to please both the ship's passengers and the crew and claimed that he had "never known so good a seaboat.... Every day the passengers were at meals. It is very different providing passengers with dinner every day, instead of having a large number sick as in other ships."[88] Moreover, the *Times* reported: "The voyage was much enhanced by the gentlemanly and patriotic Capt. Walter Paton, who is becoming a great favorite with the American traveling public."[89] The company earned £500 (after paying the interest and the costs) and was only £2000 in debt. The ship required no financial investment, for she was ready for ocean service, but £5000 was needed to make her next trip possible.

Mainly because of Paton's character, the shareholders provided the money without any resistance.[90] On July 11, 1862, the *Great Eastern*, with 376 passengers, reached New York and on her return trip, she carried 500 passengers.[91] More importantly, she was loaded with 8000 tons of wheat and set the new world's record for a load carried on a single trip.[92] Daniel Gooch and the company finally made a significant profit of £45,000. By making only two trips without a single mishap, the *Great Eastern* was capable of putting the competition out of business:

> She was the talk of the steamship business, with her ten-day crossings, her fabulous earnings and the popularity of Captain Walter Paton, who knew how to turn a ship and attract passengers. Rival ship owners shook their heads when they thought of what she was going to do if she ever filled her projected four thousand berths.[93]

In this short period, the *Great Eastern* actually became a successful ocean liner, a fact most historians have ignored. The ship had finally won the public's trust and was being chosen over other slower and smaller ships. Consequently, on her next trip on August 17, 1862, she carried to New York a record-breaking number of 820 passengers and a full load of British merchandise.[94] Although she encountered a heavy storm, Captain Paton arrived in America on schedule on August 27. However, because the ship was overloaded and drew 30 feet (10.5m) of water, the captain was unable to sail her though Sandy Hook (the typical route) and was forced to go across the Endeavor Shoals, which were over 36 feet deep at their shallowest point. At 1:30 am, the pilot took command to guide the ship safely across the shoals, and at 2 am, the captain and the bridge crew noticed a "dull rumble."[95] Shortly after this noise had been recorded, the ship arrived near Manhattan where the passengers and cargo were safely unloaded. No one knew then that the ship was heavily damaged.

Brunel's double hull design and cellular bottom withstood damage to the ship's flat bottom that left a hole 30 meters long and 2.7 meters wide, equal to the size of a small ship. Such underwater damage, to a ship that did not sink, was never recorded before or after in maritime history. By comparison, the *Titanic,* which sank in 1912, suffered far lesser underwater damage and went down, while the *Great Eastern* was unaffected by an accident that would have sent any other ship in existence straight to the bottom within minutes. Her survival might have been the crucial turning point in the ship's history, for the disaster could have easily been made into a success proving her unprecedented safety and durability, but for reasons unknown, the company did nothing to advertise her success; instead, they postponed her next trip until an inspection was made of the hull. When the inspection revealed a large hole in the bottom of the ship, the next trip was canceled, although the ship could have sailed to England since her second bottom was in perfect condition. However, because the *Great Eastern* had developed a starboard list, Captain Paton decided to stay in America instead.[96]

The most important aspect of this accident was that the *Great Eastern* proved to be exceptionally safe. Any other ship would have sunk within minutes once its bottom had been ripped open, but the *Great Eastern's* double cellular skin made the accident almost unnoticed by the passengers or the crew. No dry dock in the world was big enough to admit the *Great Eastern,* and her flat bottom made repairing on dry land impossible, even if she could have been somehow dry-moored. The Renwick brothers proposed to repair the ship underwater. This decision resulted in a long and dangerous process involving many problems. The main problems were how to drill the rivet holes underwater, how to place them, and finally, where to get the metal plates required to repair the bottom. The biggest problem, of how to work under the water, was solved by building a dry wooden tunnel that extended above the water line. The hull was repaired at the end of December, and the *Great Eastern* was declared seaworthy.[97] The bill for repairs was $350,000 (£70,000), and the company was ruined again.

The *Great Eastern* made two more trips to New York, but the Civil War greatly limited the trade and passenger travel. 1863 ended with a loss of £20,000 for the company.[98] However, she was still a sensation, and many countries, especially France, were interested in her. The company thus decided to offer the ship as a lottery prize.[99] The tickets were to be made available in all of Europe, but unfortunately, the plan did not work and the directors, now some £170,000 in debt because of the ship's misfortunes, decided to put her up for auction. Thus, the third owners of the great ship were ruined by her mishaps, although they had been so close to success.

The ship was put up for auction, and Joseph Cunard, the owner of the world's most successful ocean line, acted as the auctioneer.[100] No bid was made, and no one was prepared to buy the great ship. Daniel Gooch, still under the spell of the *Great Eastern* and loyal to the memory of his friend Brunel, and with his two friends Brassey and Barber, at the next auction purchased the ship for £25,000.[101]

Meanwhile, Cyrus Field's company was attempting to lay the first transatlantic cable and was looking for a ship big enough to do the job. The *Great Eastern*, at that time, was the only vessel in the world that could carry the immense weight of the cable. Consequently, Gooch rented the *Great Eastern* to Cyrus Field's company. The ship was rented for free, but the cable company had to pay all the expenses, and upon successful completion of the line, to give Gooch $250,000 in cable stocks.[102] The once graceful and lavishly decorated ocean liner was converted into a cable ship. All of her interior was removed and converted into cable tanks, and one of her smokestacks was removed to make more room. By May 1865, the *Great Eastern* had been loaded with the transatlantic cable. Her new skipper was Captain Halpin. She proved to be the ideal vessel for this job, for her huge flat bottom made her stable while her side wheels, combined with the screw, made her much more maneuverable than any other ship, and her size enabled her to carry the immense amount of cable. After losing the cable twice on the first attempt in 1865, the company finally succeeded on Friday, July 27, 1866, and the Old World was connected by wire to the New World. Moreover, between 1865 and 1874, the *Great Eastern* laid five Atlantic cables and repaired four of them. Each adventure was a story of struggle against the forces of nature, but she suffered not a single fatal mishap. Thus, for nine years, she was a successful cable ship, not carrying a single passengers to America, except in 1867. James Dugan concluded: "Her cable successes permitted the *Great Eastern* a sentence in the history of the nineteenth century."[103]

Her days as an ocean liner appeared to be over, but after all the mishaps that had prevented her possible success, for the first and last time fortune turned her way. Emperor Napoleon III of France dreamed of a Universal Exhibition that would eclipse all others, but he needed a way to move thousands of rich Americans from New York to Paris, and the *Great Eastern* was his answer.[104] Gooch chartered the ship to the young Emperor, who formed the Company of Great Eastern Charters and raised $400,000 capital.[105] The great ship was once again restored to her original shape, refitted as an ocean liner, and prepared to carry 4000 American passengers. The cost of these repairs and the finishing of Brunel's original design was $500,000 (£100,000), paid by the Napoleon III and the new company.[106] The ship sailed once again to New York on her maiden French voyage on March 26, 1867, from Liverpool, with only 123 passengers on board. Some days before, Jules Verne embarked on the ship. His writings indicate that the French were determined to finish the ship according to Brunel's original design, as Verne wrote about the unsuccessful attempts to attach smaller steamers to her sides.

> A small steamer, intended as a shore boat for the *Great Eastern*, came alongside. Her movable engine was first hoisted aboard by mean of windlasses, but as for the steamer herself, she could not be embarked. Her steel hull was so heavy that the davits to which she was attached bent under the weight. Therefore, they were obliged to abandon the steamer.[107]

As the *Great Eastern* was leaving Liverpool, her ten-ton anchor was being raised by the use of an engine and a hand-operated capstan. When the anchor was half way up, the engine quit, and the ten-ton weight rested entirely on the hands of the five-crew men. The capstan wooden pins snapped, and the anchor dropped, so that the great ship claimed 4 more lives. Only one passenger disembarked because of this accident, and Jules Verne noted: "These unhappy men. Killed and wounded, were only tools, which could be replaced at very little expense."[108] The ship sailed, and her ill fortune attended her in this trip as well. New York had not seen the monster ship for four years and was enthusiastically awaiting her. Her trip was to take 10 days, as usual, but after she did not appear on the eleventh day, or even three days later, the public became aware that something had gone wrong on this voyage.

The *Great Eastern* had encountered a cyclone, whose gigantic waves had smashed her deck, so that over 200,000 liters of water were reported to have entered the ship.[109] As it had done previously, Brunel's design proved to be superior even to the most violent forces of nature, and the ship survived although Jules Verne claimed during that voyage, that nothing made by man could resist the forces of the sea:

> I was really astonished at the Captain's obstinacy. The sea swept right across the deck at the bows. I watched this grand sight; this struggle between the giant and the billows, and to a certain extent I could sympathize with the Captain's willfulness; but I was forgetting that the power of the sea is infinite, and nothing made by hand of man can resist it.[110]

The *Great Eastern* proved Jules Verne wrong, as four days after her due date, she arrived in New York, on her own power. The cyclone damaged her internal parts and caused the death of one sailor, who was killed by a broken piece of the ship, becoming the ship's 28th and last known victim. The *Great Eastern*'s losses were estimated at $100,000 (£20,000). Afterwards, the 4000 American passengers who had been expected to travel on her to the Paris Exhibition never became a reality, and she steamed back to England, carrying only 191 passengers. New York was never to see her again.

In 1874, a ship named *Faraday* was launched. She was an average steamer but custom-built especially for the purpose of telegraph construction and repairs, so the *Great Eastern* was out of a job, and her days as an ocean passenger vessel were over. Daniel Gooch, who had devoted most of his life to the ship and to the memory of his friend Brunel, took her back to Milford Haven in 1874. On this final trip, Gooch wrote:

> It may be a long time before I have a sail in the old ship again, as I do not know how we are going to employ her in the future. But we will not give up hope that some useful work will be found, as she is a noble ship and has done good service in the past.[111]

Captain Halpin commanded her on this voyage to her resting place at Milford, and on that trip, the paddle engines were used for the last time. The ship and her engines were at first attended by paid caretaker George Beckwith, but as the money ran out, the great ship was left to rust. Milford's harbour officials wanted to get rid of the rusting colossus, for she was blocking half of the port [illustrations 22 and 23], but Gooch refused to move her. In 1876, Milford's officials decided that the port would have the largest dry-dock in the world constructed in it, but one huge problem was holding back the work, for the enormous *Great Eastern* was blocking the harbour. James Dugan suggested that the angry workers planned to blow the ship up[112]; moreover, he claimed that the dock's engineer, Frederick Appleby, when he saw the great ship refused to destroy her and decided to build the dry dock around her.[113] Whether his love for the ship was truly his motivation, as Dugan argued, or whether Appleby simply needed her as a construction platform, is irrelevant. What is important is that the ship was saved, but with bad consequences for the dock's engineer.

When the dry-dock was finished, Appleby appeared to have been entirely successful, and his idea to use the monster ship as a construction platform seemed to have been justified. However, in order to use the dock for its intended purpose, he had to move the *Great Eastern* out of it. At that point, he discovered that she would not fit through the dock's gate. Appleby calculated that by removing the side-wheels from the *Great Eastern,* he would gain the needed clearance for the ship to pass through the gate. He spent most of his money to get the side wheels removed, and he managed to get the ship through, but he had to reinstall them, in a process that swallowed all of his money.[114] The *Great Eastern* thus ruined another person connected with the ship although Appleby's dock outlived the monster and is still in use.[115]

The ship up until then was the property of Daniel Gooch, but he was ageing, and in 1880, he gave the *Great Eastern* to Brassey's son, Henry, who became yet another owner who failed to make any profit out of the ship. Unable to find any use for her, he

Illustration 22. The last years of the *Great Eastern*'s life in Milford Haven.

Illustration 23. A sail ship completely dwarfed by the *Great Eastern*'s gigantic hull.

gave her up, and in 1885 she was offered once again at an auction. Edward de Mattos purchased the ship for £26,200.[116] His company, London Traders, had plans to use her gigantic hull as a coaling hulk in Gibraltar.[117] However, due to some political difficulties, the new owner was unable to employ the ship as a coal station and agreed to charter the ship to Louis Cohen, a representative of the Lewis Company. The company's owner, David Lewis, truly loved the ship and raised £20,000 to save her, but he died before the auction. As James Dugan wrote, "David Lewis had died on the eve of the auction and left Louis Cohen with the sacred duty to rescue the ship."[118] The great ship was chartered, and was to be the main attraction of the Liverpool Industrial and Maritime Exhibition in 1886. However, she was unused for twelve years, her engines dead cold and rusting for eleven, and Louis Cohen had little knowledge of the ship.

On April 29, 1886, she was to steam to Liverpool with 200 important guests and her tenth captain, named Comyn. The ship by then was very rusted. James's Watts' tired engines would not start, and Russell's engines were nonfunctional and could not be used. After some difficulties, the gigantic screw engines were brought back to life, but they ran slowly at eight revolutions per minute, died three times, and ran only in reverse. When the crew tried to change the direction of the screw shaft, the old engines died. The crew needed all night to fix the air leaks and to patch the rusted steam pipes. In the morning the ship steamed at 5 knots per hour, as she made her way to the Saint Ann's Head the tired engines died again. After the crew patched more holes in the rusted pipes, the ship made some progress the next morning, but a fire broke out in the boiler room, and the engines quit for good. For safety reasons, the monster was towed. During that tow, her gigantic anchor came down on its own and almost sank a ship which was under her side. Dugan claimed: "She [the *Great Eastern*] was still too big for the ships. Captain Duff's damage report is the last known evidence of her awkwardness. She was still hitting them after thirty years; the Wrestler was the tenth vessel she had damaged or sunk."[119] This statement is highly exaggerated, for the *Great Eastern* did not sink any ships. She sank river barges.

Her arrival in Liverpool proved to be a tremendous success, for the city has not seen the giant ship for eighteen years, and her arrival caused a sensation. Edwin Charles Lowe wrote, "What a contrast! Then [1861] she was in full bloom and a vessel of great expectations in spite of all her slanders. Now she is mammoth advertisement. How are the mighty fallen!"[120] The ship was turned into a show-boat, and many people, as Lowe indicated, would have preferred to see her die rather than be disgraced in such a manner:

> The effect upon me was most saddening. We all know that the life of the *Great Eastern* had been a failure, an arrow that has missed its mark. Anything I should think would be better than the life she is leading. If she cannot pay a breaking-up price, let her be decently buried beneath the wild billows of the great Atlantic. I for one will contribute to her funeral expenses.[121]

However, the half-million visitors who came to admire her and paid to see the *Great Eastern* proved what a sensation she still was so many years after her construction. Brunel's ship was still fascinating people and became the main attraction of the Liverpool Exhibition. "The Liverpool Exhibition didn't turn out to be much of an attraction; the *Great Eastern* stole the show.... They didn't leave much money in Liverpool. Lewis seemed to be getting it all."[122] When the charter expired in 1886, the ship was returned to her seventh owner, Edward de Mattos, but his plan to use the great ship as a coalbunker failed, and he could find no other use for her than turning her into an advertisement platform for the Lewis Company. Finally being unable to make any money from her, he put the rusting monster up for auction. On October 20th, 1887 the auction took place, and the ship was not sold. A month later, a "melancholy fifth auction [took place], de Mattos received an offer of £16,000 From Henry Bath & Sons…. They were in the unsentimental business of breaking ships."[123] Once the pride of Great Britain and the entire industrial world, Brunel's grand vision of a gigantic ocean liner was to be destroyed and turned into scrap, but in her last days, she provided everlasting testimony of how superbly she was built and designed, as the demolitions crew was unable to take her apart.

This chapter has explored in detail the *Great Eastern*'s career at sea and her major mishaps such as the feedwater explosion, various violent storms that she have survived, and the tearing of her cellular bottom. The chapter argued that her ability to survive her misfortunes proved how successful her design was, and that her design influenced the future great ocean liners of the 20th century. The chapter also demonstrated that she was, in fact, fully successful in carrying thousands of troops across the Atlantic at an intended record speed of about 15 knots per hour, yet due to financial cuts, she was never properly outfitted to carry such a number of passengers. This point was demonstrated by the detailed description of her first trip to America, during which the *Great Eastern* failed to establish herself as a passenger vessel due to her inadequate accommodations for passengers and the complete unfitness of her crew for passenger service. The main point that the chapter stressed was that the *Great Eastern* was a tremendous engineering and technological success, yet because of her owners' mismanagement and unprecedented bad-luck, the ship failed to become an ocean liner.

Notes

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[1] Quoted by John Pundney in Brunel and His World, p. 106.

[2] L.T.C. Rolt, Isambard Kingdom Brunel, p. 296.

[3] James Dugan, The Great Iron Ship, p. 39.

[4] L.T.C. Rolt, Isambard Kingdom Brunel, p. 295.

[5] L.T.C. Rolt, Isambard Kingdom Brunel, p. 296.

[6] James Dugan, The Great Iron Ship, p. 43.

[7] L.T.C. Rolt, Isambard Kingdom Brunel, p. 296.

[8] The Times quoted by L.T.C. Rolt in Isambard Kingdom Brunel, p. 297.

[9] Quoted by James Dugan in The Great Iron Ship, p. 43.

[10] Quoted by James Dugan in The Great Iron Ship, p. 43.

[11] L.T.C. Rolt, Isambard Kingdom Brunel, p. 297.

[12] L.T.C. Rolt, Isambard Kingdom Brunel, p. 297.

[13] L.T.C. Rolt, Isambard Kingdom Brunel, p. 297.

[14] L.T.C. Rolt, Isambard Kingdom Brunel, p. 297.

[15] James Dugan, The Great Iron Ship, p. 44.

[16] London Illustrated, “The Great Eastern”, No. 993, Vol. XXXV, Saturday, September 17, 1859, p. 263.

[17] James Dugan, The Great Iron Ship, p. 45.

[18] James Dugan, The Great Iron Ship, p. 44.

[19] London Illustrated, Supplement, “Brunel”, No. 995, Vol. XXXV, Saturday, September 24, 1859, p.303.

[20] Daniel Gooch quoted by John Pundney in Brunel and His World, pp. 107-108.

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[21] Quoted by John Pundney in Brunel and His World, p. 106.

[22] Sally Dugan, Men of Iron, p.160.

[23] L.T.C. Rolt, Isambard Kingdom Brunel, p. 295.

[24] Quoted by L.T.C. Rolt in Isambard Kingdom Brunel, p. 295.

[25] L.T.C. Rolt, Isambard Kingdom Brunel, p. 300.

[26] The Times quoted by L.T.C. Rolt in Isambard Kingdom Brunel, p. 300.

[27] James Dugan, The Great Iron Ship, p. 45.

[28] L.T.C. Rolt, Isambard Kingdom Brunel, p. 302.

[29] James Dugan, The Great Iron Ship, p. 45.

[30] James Dugan, The Great Iron Ship, p. 45.

[31] James Dugan, The Great Iron Ship, p. 45.

[32] James Dugan, The Great Iron Ship, p. 45.

[33] James Dugan, The Great Iron Ship, p. 46.

[34] James Dugan, The Great Iron Ship, p. 46.

[35] James Dugan, The Great Iron Ship, p. 48.

[36] James Dugan, The Great Iron Ship, p. 35.

[37] James Dugan, The Great Iron Ship, p. 55.

[38] Holley quoted by James Dugan in The Great Iron Ship, p. 55.

[39] James Dugan, The Great Iron Ship, p. 57.

[40] James Dugan, The Great Iron Ship, p. 57.

[41] Quoted by James Dugan in The Great Iron Ship, p. 61.

[42] Daniel Gooch quoted by James Dugan in The Great Iron Ship, p. 63.

[43] James Dugan, The Great Iron Ship, p. 64.

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[44] James Dugan, The Great Iron Ship, p. 68.

[45] The ship, thus, had claimed 21 lives. James Dugan counted 22 at this point; however, it is unclear where he obtained one 'extra' person; most likely, he counted the missing basher boy or Brunel as a victim.

[46] James Dugan, The Great Iron Ship, p. 72.

[47] Henry Fry, The History of North Atlantic Steam Navigation p. 182.

[48] James Dugan, The Great Iron Ship, p. 76.

[49] Holley quoted by James Dugan in The Great Iron Ship, p. 78.

[50] The Times quoted by James Dugan in The Great Iron Ship, p. 78.

[51] The Times quoted by James Dugan in The Great Iron Ship, p. 80.

[52] Harper's Weekly quoted by James Dugan in The Great Iron Ship, p. 83.

[53] James Dugan, The Great Iron Ship, p. 85.

[54] James Dugan, The Great Iron Ship, p. 85.

[55] James Dugan, The Great Iron Ship, p. 86.

[56] James Dugan, The Great Iron Ship, p. 86.

[57] James Dugan, The Great Iron Ship, p. 92.

[58] James Dugan, The Great Iron Ship, p. 92.

[59] L.T.C. Rolt, Isambard Kingdom Brunel, p. 312.

[60] James Dugan, The Great Iron Ship, p. 93.

[61] The Times quoted by James Dugan in The Great Iron Ship, p. 93.

[62] James Dugan, The Great Iron Ship, p. 97.

[63] James Dugan, The Great Iron Ship, p. 101.

[64] James Dugan, The Great Iron Ship, p. 104.

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[65] The Great Eastern's logbook quoted by James Dugan in The Great Iron Ship, p. 106.

[66] Passenger Forwood quoted by James Dugan in The Great Iron Ship, p. 106.

[67] Passenger Percy de Corwin quoted by James Dugan in The Great Iron Ship, p. 106.

[68] James Dugan, The Great Iron Ship, pp. 107-108.

[69] James Dugan, The Great Iron Ship, p. 108.

[70] James Dugan, The Great Iron Ship, p. 109.

[71] James Dugan, The Great Iron Ship, p. 109.

[72] James Dugan, The Great Iron Ship, p. 110.

[73] James Dugan, The Great Iron Ship, p. 112.

[74] Passenger Forwood quoted by James Dugan in The Great Iron Ship, p. 111.

[75] Passenger Forwood quoted by James Dugan in The Great Iron Ship, pp. 116-117.

[76] Captain Walker quoted by James Dugan in The Great Iron Ship, p. 115.

[77] James Dugan, The Great Iron Ship, p. 116.

[78] James Dugan, The Great Iron Ship, p. 117.

[79] James Dugan, The Great Iron Ship, p. 120.

[80] James Dugan, The Great Iron Ship, p. 121.

[81] James Dugan, The Great Iron Ship, p. 125.

[82] James Dugan, The Great Iron Ship, p. 127.

[83] James Dugan, The Great Iron Ship, p. 131.

[84] James Dugan, The Great Iron Ship, p. 127.

[85] James Dugan, The Great Iron Ship, p. 127.

[86] Vernon Gibbs, Passenger Liners of the Western Ocean (London: Staples Press, 1957), p. 361.

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[87] James Dugan, The Great Iron Ship, p. 134.

[88] Captain Paton quoted by James Dugan, The Great Iron Ship, p. 137.

[89] The Times, quoted by James Dugan, The Great Iron Ship, p. 137.

[90] James Dugan, The Great Iron Ship, p. 137.

[91] James Dugan, The Great Iron Ship, p. 137.

[92] James Dugan, The Great Iron Ship, p. 139.

[93] James Dugan, The Great Iron Ship, p. 139.

[94] James Dugan, The Great Iron Ship, p. 139.

[95] James Dugan, The Great Iron Ship, p. 140.

[96] James Dugan, The Great Iron Ship, p. 146.

[97] James Dugan, The Great Iron Ship, p. 154.

[98] James Dugan, The Great Iron Ship, p. 159.

[99] James Dugan, The Great Iron Ship, p. 160.

[100] James Dugan, The Great Iron Ship, p. 160.

[101] L.T.C. Rolt, Isambard Kingdom Brunel, p. 305.

[102] James Dugan, The Great Iron Ship, p. 167.

[103] James Dugan, The Great Iron Ship, p. 217.

[104] James Dugan, The Great Iron Ship, p. 190.

[105] James Dugan, The Great Iron Ship, p. 190.

[106] James Dugan, The Great Iron Ship, p. 192.

[107] Jules Verne quoted by James Dugan, The Great Iron Ship, p. 193.

[108] Jules Verne quoted by James Dugan in The Great Iron Ship, p. 194.

[109] James Dugan, The Great Iron Ship, p. 198.

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[110] Jules Verne quoted by James Dugan in The Great Iron Ship, p. 197.

[111] Daniel Gooch quoted by James Dugan in The Great Iron Ship, p. 240.

[112] James Dugan, The Great Iron Ship, p. 241.

[113] James Dugan, The Great Iron Ship, p. 241.

[114] James Dugan, The Great Iron Ship, p. 242.

[115] James Dugan, The Great Iron Ship, p. 242.

[116] James Dugan, The Great Iron Ship, p. 244.

[117] James Dugan, The Great Iron Ship, p. 244.

[118] James Dugan, The Great Iron Ship, p. 245.

[119] James Dugan, The Great Iron Ship, p. 250.

[120] Edwin Charles Lowe quoted by James Dugan in The Great Iron Ship, p. 251.

[121] Edwin Charles Lowe quoted by James Dugan in The Great Iron Ship, p. 252.

[122] James Dugan, The Great Iron Ship, p. 256.

[123] James Dugan, The Great Iron Ship, p. 261.

Chapter 5

Conclusions: The End and the Legacy of the *Great Eastern*

The last owners of the *Great Eastern*, Henry Bath and Sons Company, purchased her in order to make money from her destruction, as they planned to demolish the ship and profit from the salvaged iron. James Dugan indicated that the new owners, although 'unsentimental,' were, like so many people before them, fascinated by the great ship and at first were unwilling to destroy her.[1] They made plans to repair the *Great Eastern* and put her back into the ocean service. The new owners needed a dry dock to perform all the repairs, and their previous agreement made with Captain Barnett allowed them to use the dock for the purpose of breaking up the ship. However, once Barnett discovered that they planned to rescue the *Great Eastern*, he terminated their contract.

> They [the new owners] gazed upon their big possession and the sight stole their reason. They began mooning to each other about moving the old engines, installing new ones and making pay in the cattle trade, or perhaps in carrying bulk petroleum. They went back to Barrow to arrange for a refit in Ramsden Dock, Captain Barnett saw the fever in their eyes and refused to let them have the dock.[2]

The last chance of saving the ship was lost. However, on August 22, 1888, her gigantic steam engines were brought back to life once more. She barely made 4 knots[3] before the engines give out. These worn-out and very old creations of James Watt quit for the last time. The ship was from then on towed, never to steam entirely on her own power again. As she was taken towards Liverpool, a heavy storm developed, and the crew of the tugboat *Stormcock* disconnected the tow cable. Over 100 people were on board the *Great Eastern*, and their lives were in danger as the ship was once more left facing the storm with her side open to the wind. *Scientific American* reported:

> …the Great Eastern was sent on her lat voyage to the Mersey, where, recently she was beached near New Ferry, on the Cheshire shore, to be eventually handed over to the dismantling hammer. Even to the last her ill-fortune appeared to attend her, as during her journey from the Clyde she encountered a gale, during which the tug was obliged to cast her loose…. The great vessel became unmanageable, and for hours rolled about at the mercy of the wind and waves.[4]

This storm was the last that the *Great Eastern* encountered on water. The storm and the ship claimed no victims this time. Afterwards, she was put up for her last auction. Sir Daniel Gooch, when he read about the final sale, wrote in his diary: "Poor old ship, you deserved a better fate."[5] In October 1889, Sir Daniel Gooch died; the ship had outlived him, as well as Russell, who had died in 1882.

The final auction proved to be a financial success. Henry Bath and Sons Company purchased the ship for £16,000, but her parts were sold for much more. The *Great Eastern*'s 3,000,000 rivets and 30,000 plates went for £25,000, her fittings brought £24,000 and the gigantic anchors £300. The remaining individual parts were sold for £8,700. Thus, her sale brought the company £58,000.[6] For the first time, owners of the great ship had made a noticeable profit, as the *Scientific American* noted:

> The sellers were Bath & Co., of Liverpool, who paid $80,000 for the vessel and sold her out at auction for $290,000, thus realizing a handsome profit, being, we believe, the first and only profit ever made by the unfortunate ship for any of her various owners.[7]

However, in order to collect the money, the new owners had to break up the ship. This process provided the final proof of how durable and well constructed she was.

The inglorious process of breaking-up the *Great Eastern* began 31 years and 3 months after her launching, in May 1889. The removal of the internal fittings went well, but once the workers attempted to demolish the double iron hull, the work ceased. No cutting torches were available at that time, and ships were dismantled by hand. As a result, each of the three million rivets had to be hand cut or grounded flat and then removed. Doing so proved almost impossible; the old ways of breaking up ships failed, and the great ship challenged the contemporary iron salvage technologies. The Bath and Sons Company, to overcome the ship's unprecedented strength, invented a new method for demolishing ships: they used a big iron ball that was hoisted above the ship and then released, crushing the tired outer skin of the *Great Eastern*. The process was long, and the demolition crew took almost two years to reach the ship's double bottom, and at that point, the workers quit. They were paid by the ton, and the cellular bottom resisted both the iron ball and the hand operated chisels. However, after the shipbreakers were paid on a different basis, the work was resumed. Consequently, by the end of 1891, one of the "most daring adventures in shipbuilding"[8] had ceased to exist, the work of the breakers was finished, and so was the life of the *Great Eastern*.

The history of the great ship was dominated by misfortunes, bad management, and human errors. Our inquiry demonstrated that the ship was extremely well designed and withstood more damage and forces of nature than any other vessel. This study also revealed that Brunel's design had only four major problems that repeatedly caused damage to the ship and harm to people. First, the skylights were placed too low on the deck. They crashed in almost every storm and resulted in repeated damage done to the ship's great saloon. Second, the gigantic side wheels proved to be highly unfunctional on the high seas, and poorly constructed. The ship lost her side wheels' wooden floats many times during her life, suggesting that they should have been constructed of iron rather than wood. Third, the ship was designed without internal heaters and thus could not sail in the winter or successfully carry passengers across the cold North Atlantic.

However, when Brunel designed the *Great Eastern*, she was to steam to warm Australia and India; thus, the design was adequate for the ship's intended purpose. Nevertheless, this design also made the ship useless for half of the sailing season on the cold Atlantic routes.

The last and perhaps the biggest problem that Brunel had overlooked when designing the great ship was its heavy rolling on the high seas. Brunel's design eliminated the traditional keel and replaced it with a flat-bottom design. The extensive flat surface, however, was not enough to provide the ship with the necessary stability on the Atlantic's stormy waves. The ship rolled up to 48 degrees, that is, to the point that she was almost capsizing, and her gigantic paddle boxes were submerged entirely under the water. The *Great Eastern*, thus, was rolling more than any ship at that time and probably at any time. The solution to this problem was invented some years later in the early twentieth century. To make the gigantic flat-bottomed hulls stable, thin metal plates were attached to each side of a ship at the point where the ship's sides joined the bottom. These devices became known as the 'stabilization plates.'

These four problems in design were the major ones that, to some degree, affected the ship's success in becoming an ocean liner. However, the major factors that affected the *Great Eastern*'s career were the bad management and the constant mishaps and deaths associated with the ship, which give her a bad reputation and made her known as a 'jinx ship'. Certainly, it is impossible to historically determine why the great ship was so unlucky, that is, why she suffered so many mishaps during her career. The ghost-story theory, which James Dugan promoted, and, in the end, an eyewitness supposedly confirmed, seems to be a rather poor explanation. Trying to find a possible direct cause of the ship's bad-luck is impossible without looking at the matter from a metaphysical perspective. Since this paper did not take such an approach, we have to leave this question unanswered and examine only the results of the *Great Eastern*'s ill-fortune, rather than search for its cause. Although the cause of the ship's bad luck cannot be found, this paper suggested two possible reasons for her constant delays and mishaps. One was the involvement of Scott Russell in the project, and the other the mismanagement of the ship by her various owners.

Russell's constant miscalculations, lack of cooperation, and disregard for deadlines directly contributed to the ship losing her identity as a predictable passenger vessel. Moreover, as it was discussed, predictability was by the 1860' s the crucial factor that made a passenger ship successful, so the delays caused by Russell greatly limited the public's trust in the *Great Eastern*'s predictability and thus made her almost useless as an ocean liner.

The mismanagement of the ship's owners was, in fact, the reason why the *Great Eastern* had never sailed to Australia even though she had been built for that purpose. As early as the 1860's, W. Hawes, a chairman at a meeting of the *Great Eastern*'s shareholders, noticed that "management had caused all the *Great Eastern*'s troubles: Gooch, Barber and Company had made their greatest error in putting her on the Atlantic instead of the Indian or Australian run for which she was designed."[9] Unfortunately, their reasons for making this decision were not reported. This decision greatly added to the *Great Eastern*'s financial problems and also indicates how badly the ship was managed.

The purpose of this thesis was to challenge the theory that the *Great Eastern* was a failure. As we have discovered, on many occasions, she was fully successful, but every time when she was close to becoming a successful ocean liner, a mishap occurred causing death to the people associated with the ship and almost destroying the vessel. Each time, however, the *Great Eastern* survived her mishaps, proving that, in fact, her design was supreme and successful as an ocean vessel. Thus, although she was without doubt one of the most unlucky ships in the history, she was not a failure as a maritime design; instead, as this paper has argued, she was one of the best and, in this sense, one of the most successful ships in history. We have discovered in our study that on many occasions, the ship could have been a fully successful ocean liner if she had had effective owners. Scott Russell was not the sole cause of her failures, but one who initially contributed the most to her financial disasters. Later one, as we have discovered, the series of poorly chosen captains and crews, as well as lack of proper promotion and public relations, caused the ship to lose passengers; however, this problem was never because of her design.

If Brunel's design had been carried out entirely and properly, then the unfortunate trip to America with 2000 unhappy passengers sleeping on deck would not have taken place. Moreover, if the ship had been equipped with the intended side steamers, she would not have had to enter the ports and, thus, could have avoided many of the collisions and mishaps that took place because she had to be unloaded and loaded by the ports' inexperienced barges crews. Finally, the famous explosion on her first trip in 1859, which undermined from the start the public's confidence in the great ship, would not have taken place if Brunel's plans had been properly carried out. All this evidence signifies that many of *Great Eastern*'s misfortunes could have been, in fact, avoided if the ship had been built according to Brunel's original design. The miscalculations of Scott Russell caused the necessary cuts in the expenditures, and eliminated many of the ship's intended features.

Thus, the *Great Eastern* did not become a successful ocean liner because of her countless mishaps, the mismanagement, and the lack of funds to properly outfit her in accordance with Brunel's original design. This paper supported this conclusion by providing detailed accounts of the *Great Eastern*'s seven owners and their financial struggles. The great ship's failure should thus be reconsidered. The ship was not a failure; it was, rather, a huge engineering success, but the incompetence of her owners and her misfortunes overshadowed her life as an ocean liner.

This thesis also demonstrated through the study of various primary materials that the only complete book on the subject, *The Great Iron Ship* by James Dugan, cannot be entirely relayed upon as a trustworthy historical source. The study also revealed that all of the secondary sources overlooked crucial technical descriptions of the role and the design of feedwater heaters, the launching technique and equipment designed for this purpose, as well as the correct chronology of events. A more correct chronology and the ship's specifications were difficult to establish, mainly because of the overwhelming amount of the primary sources which, on many points, contradict each other. However, whenever possible, this paper demonstrated the most probable numbers based on the legitimate primary materials, mainly the *Scientific American*. Although the secondary sources presented many problems, and at many points, the paper argued against James Dugan's depiction of events, the latter part of his book is, in fact, a valuable source for the primary materials regarding the ship's carrier after the death of her designer. Thus, although this paper argued against Dugan's main arguments that the ship was a technological failure and that her bad-luck was possibly caused by the ghost of a worker who had been sealed alive in the hull's double shell, the thesis fourth chapter depended largely on the sources that Dugan presented in his book, which are otherwise inaccessible, and to some degree, this paper followed Dugan's chronology of later events.

The second aim of the paper was to demonstrate that Brunel's innovations and his design have helped to create the modern ocean liner and have influenced maritime design so greatly that, many of the *Great Eastern*'s features are still being used in the modern shipping industry. This fact also strengthens the proposed revaluation of the *Great Eastern* as a shipping failure, for if she really were a failure, why have her design and innovations been used successfully for over 145 years? The answer that this thesis is proposing is that the *Great Eastern* was not a failure but an engineering success.

The rib-less hull design revolutionized the shipbuilding industry and made possible the construction of even greater ships, such as the *Lusitania*, *Olympic* and *Titanic*. The previous method of shipbuilding made such construction impossible. The wooden ribs of the ships limited their shape and also limited their size to about 100 m in length. Brunel's invention enabled the ships to be built out of iron plates that were later riveted to the web of bulkheads. Moreover, his cellular bottom design is now used on all ocean-going ships and is mandatory on all large sea vessels. His watertight compartments were also used on all modern ocean liners and, with a few modifications, are being used today. Most importantly, his hull design, with the flat bottom, also influenced all of the gigantic ocean liners of the early twentieth century and gave them their distinctive look. As this paper argued, it was no coincidence that the hulls of ocean liners up until 1935, when the French launched the *Normandie*, resembled in shape Brunel's and Russell's design. The *Great Eastern*, moreover, proved once and for all that the gigantic ships were a reality. Before Brunel launched his monster, many engineers and people connected to maritime design had argued that the rib-less design and immense weight would cause a vessel to break in half on the ocean waves.[10] The great ship proved them wrong and thus supplied the necessary proof of the engineering possibilities of Brunel's design.

The *Great Eastern* also influenced the creation of the gigantic ocean liners in another manner. Her enormous hull, designed to carry up to 10,000 passengers in case of a war, was finally appreciated by the navy. Consequently, later ocean liners, starting with the *Lusitania*, were largely subsidized by the government. In the case of war, as during WWI, these gigantic ships were converted into hospitals and troop carriers. Such a concept had been unknown previously. The *Great Eastern*'s trip to Canada in 1861 made this obvious use of the gigantic passenger vessels apparent to the military. Thus, although the *Great Eastern* failed to carry thousands of passengers across the oceans, she was successful as the model for future maritime developments. She was a model so good that some of her innovations are now a vital part of the modern shipping design. However, the argument of the paper was not based on technological- determinism, for the crucial argument that the paper conveyed was that Brunel's ship was an important and successful step in the development of the gigantic ocean liners rather than the cause of it.

Thus, the *Great Eastern* was a success rather than failure, in three major ways. First, she successfully proved that the gigantic iron ship was a reality, and much more safer and durable than any other maritime design. Second, she was successful as the model for future shipping designs and proved to be the way of the future maritime developments. Third, she faced more mishaps and dangers than any other ship in history, and she was successful in overcoming each of these misfortunes, withstanding forces of nature that would sink or destroy any other vessel in existence. For all these reasons, the *Great Eastern* was a tremendous success, rather than a failure, and thus should be regarded as not only one of the most unlucky ships of all times, but also as one of the most successful in influencing the future maritime developments. The best evidence for this claim comes from the change in the Cunard Line, the most successful ocean line in the world. The Cunard Line was based on the premise that a fleet of small slow but durable and predictable ships was much better than any gigantic ship. For this reason, they were never interested in the *Great Eastern* and considered her as a waste of money and coal. In 1906, the world was introduced to another monster ship, the first vessel to reach and exceed the size of the *Great Eastern*. The new ship was the *Lusitania*, and ironically, she was proudly built and owned by the Cunard Line. This shift in maritime developments from small to the gigantic steamers is the final proof that Brunel's design of the monster ship was not a failure but a success that proved to be very influential in the future:

> Today, when the Thames tides recede, the timbers of the ways which once launched the *Great Eastern* still appear in the mud below the Napier Yard at Millwall. These timbers, with the few pathetic relics of the great ship which were preserved when she was broken up, and the hulk of the *Great Britain* in the far away Falklands, are all that now remains of the three most daring adventures

> in shipbuilding since man first ventured on the deep seas [the *Great Western*, *Great Britain* and the *Great Eastern*].[11]

All were built and designs by one man, a dreamer, poet and an engineer, Isambard Kingdom Brunel, whose determination to build the *Great Eastern* helped to bring about the era of the gigantic ocean liner which changed the world forever.

Notes

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[1] James Dugan, The Great Iron Ship, p. 261.

[2] James Dugan, The Great Iron Ship, p. 261.

[3] Scientific American, "The End of the Great Eastern", Vol. 59, September 29, 1888, p. 226.

[4] Scientific American "The Great Eastern Mowing to Her Last Berth", Vol. 59, October 13, 1888, p. 226.

[5] Sir Daniel Gooch quoted by James Dugan in The Great Iron Ship, p. 264.

[6] Scientific American "Auction Sale of the Great Eastern", Vol. 27, January 12, 1889, p. 10862.

[7] Scientific American "Auction Sale of the Great Eastern", Vol. 27, January 12, 1889, p. 10862.

[8] L.T.C. Rolt, Isambard Kingdom Brunel, p. 313.

[9] W. Hawes quoted by James Dugan in The Great Iron Ship, p. 163.

[10] James Dugan, The Great Iron Ship, p. 4.

[11] L.T.C. Rolt, Isambard Kingdom Brunel, p. 313.

Bibliography

The Illustrated London News. London: published at 198. Strand, 1851 - 1883.

The Scientific American. New York: Munn co, 1888 – 1912.

The Times. London. 1855 – 1896.

Albion, Robert. Greenhalgh. Five Centuries of Famous Ships : From The Santa Maria to The Glomar Explorer. New York : McGraw-Hill, 1978.

Bathe, Basil. Seven Centuries of Sea Travel : From The Crusaders to The Cruises. New York : Leon Amiel Publisher, 1973.

Beamish, Richard. Memoir of the life of Sir Marc Isambard Brunel. London: Longman and Roberts, 1862.

Beckett, Derrick. Brunel's Britain. Newton Abbot: David and Charles, 1980.

Bishop, Paul. Tall Ships and the Cutty Sark Races. Warsaw: Alma Press, 1996.

Borchardt, K.O. Znaczy Kapitan. Gdansk: Wydawnictwo Morskie, 1977.

Brooke, Alan. Liberty or Death: Radical Republicans and Luddites. Honley: Workers History Publications, 1993.

Brinnin, John. The Sway of The Grand Saloon; A Social History of The North Atlantic. New York : Delacorte Press, 1971.

Brock, P.W. and Greenhill, Basil. Steam and sail: in Britain and North America. Newton

Abbot: David & Charles,1973.

Buehr, Walter. The Birth of A Liner. Boston: Little, Brown, 1961.

Bull, Angela. The Machine Breakers: The Story of the Luddites. London: Collins, 1980.

Canby, Courtlandt. A History of Ships and Seafaring. New York : Hawthorn Books, 1963.

Charles, Robert, Vernon. British Passenger Liners of The Five Oceans. London: Putnam, 1963.

Clements, Paul. Marc Isambard Brunel. Harlow: Longmans, 1970.

Coleman, Terry. The Liners : A History of The North Atlantic Crossing. London: Allen Lane, 1976.

Corlett, Ewan. The Revolution in Merchant Shipping. London: H.M.S.O., 1981.

Cornwell, E. L. An Illustrated History of Ships. London: New English Library, 1979.

Mc Cutchan, Philip. Tall Ships: The Golden Age of Sail. London: Weidenfeld and Nicolson, 1976.

Dugan, Sally. Men of Iron. London: Channel Four Books, 2003.

Dugan, James. The Great Iron Ship. New York: Harper, 1953.

Florman, Samuel. The Existential Pleasures of Engineering. New York: St. Martin's Press, 1976.

Fry, Henry. The History of North Atlantic Steam Navigation. New York: Charles Scribeners's Sons, 1896.

Gibbs, Vernon. Passenger Liners of the Western Ocean. London: Staples Press, 1957.

Gould, Richard. Archaeology and The Social History of Ships. New York: Cambridge University Press, 2000.

Greenhill, Basil. Traveling By Sea in The Nineteenth Century. London: Adam & Charles Black, 1972.

Greenhill, Basil. The Life and Death of the Merchant Sailing Ship. London: W.S. Cowell, 1980.

Griffiths, Maurice. Man The Shipbuilder. London: Priory Press, 1973.

Gulas, Stefan. Zaglowce. Bratislava: Slovart, 1985.

Guthrie, John. Bizarre Ships of The Nineteenth Century. South Brunswick: A. S. Barnes, 1970.

Grabowski, Z. Tysac Slow o Morzu i Okrecie. Warszawa: Ministerstwo Obrony Narodowej, 1955.

Hay, Peter. Brunel-His Achievements in the Transportation Revolution. Berkshire: Osprey, 1973.

Hughes, Tom. The Blue Ribbon of The Atlantic. Cambridge: Stephens, 1973.

Jenkins, David. Isambard Kingdom Brunel, Engineer Extraordinary. Hove: Priory Press, 1977.

Kahre, Georg. The Last Tall Ships: Gustaf Erikson and the Aland Sailing Fleets. New York: Mayflower Books, 1978.

Karlsson, Elis. Ostatnie Zaglowce. Gdansk: Wydawnictwo Morskie, 1974.

Kemp, Peter. Encyclopedia of Ships and Seafaring. London: Stanford Maritime, 1980.

Könemann, Köln. Liners : The Golden Age = Die Grobe Zeit Der Ozeanriesen. Hulton Getty Picture Collection Ltd., 1999.

Lamont, Robert. Statement of The Principal Circumstances Connected With The Establishment Of The Line of Ocean Steamers Between Liverpool and Canada 1855, (microform).

Landström, Björn. The Ship, An Illustrated History. Garden City, N.Y: Doubleday, 1961.

Maber, John. Channel Packets and Ocean Liners, 1850-1970. London : H.M.S.O., 1980.

Maddocks, Melvin. The Great Liners. Alexandria, Virginia: Time-Life Books, 1978.

Mahan, A.T. From Sail to Steam. New York: Harper, 1907.

Maxtone-Graham, John. The Only Way To Cross. New York: Macmillan, 1972.

McCutchan, Philip. The Golden Age of Sail. London: Weidnefeld and Nicolson, 1976.

Micinski, Jerzy. Archiwum Neptuna. Warszawa: Wdawnictwo Ministerstwa Obrony Narodowej, 1957.

Moyse-Bartlett, Hubert. From Sail to Steam : The Final Development and Passing of The Sailing Ship. London: Published for the Historical Association by Staples Press, 1946.

Rosenblum, Naomi. A World History of Photography. London: Abbeville Press, 1997.

Rolt, L.T.C. Isambard Kingdom Brunel. London: Longmans, 1957.

Pugsley, Alfred. The Works of Isambard Kingdom Brunel. New York: Cambridge University Press, 1980.

Pundney, John. Brunel and His World. London: Thames and Hudson, 1974.

Smith Crosbie, Higginson Ian, and Wolstenholme Philip. Avoiding Equally Extravagance and Parsimony. The Society for the History of Technology, 2003.